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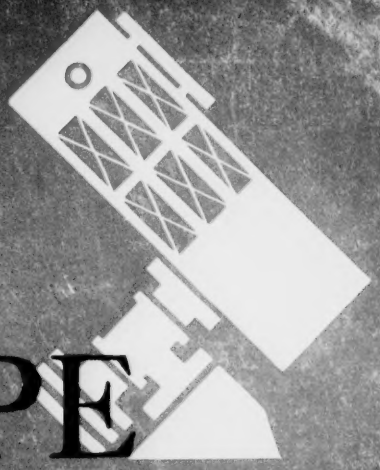

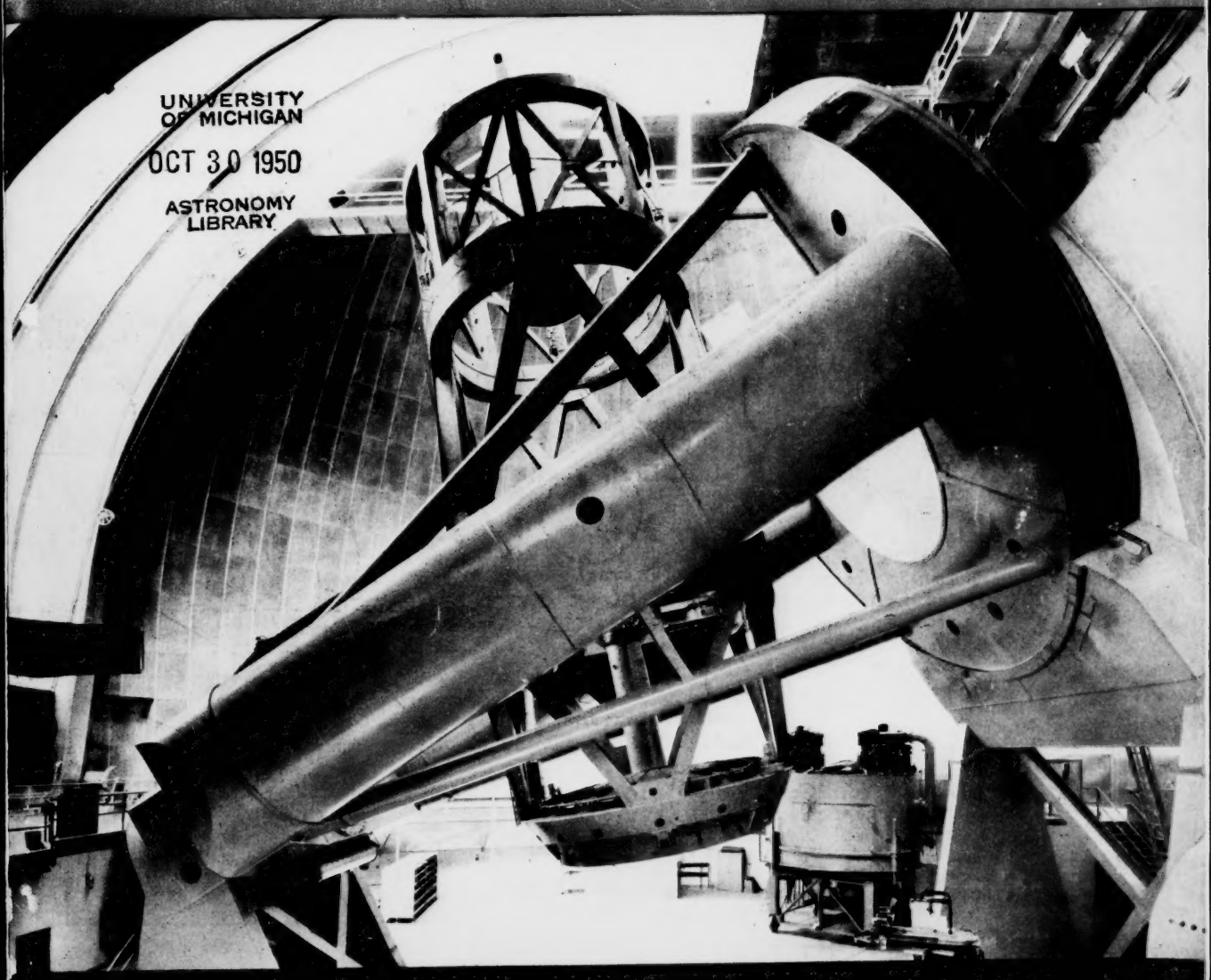

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EARTH, COMETS AND METEORITES

One of the sessions of the National Academy of Sciences, which met at the General Electric Research Laboratory in Schenectady in October, was devoted to discussions of the structure of the earth and the origin of the solar system and its constituents. It is gratifying to note how well the conclusions of many of the speakers confirmed or supplemented one another, but the need for considerable future theoretical and observational work was also evident.

Dr. Harold C. Urey, of the University of Chicago, extended his proposal of a year ago that the core of the earth was formed by the sinking of iron through its outer layers after a primitive earth of grossly uniform composition evolved (see *Sky and Telescope,* January, 1950, page 54). Now he finds, "The heat balance of the earth indicates too much heat generation if gravitational energy due to formation of the core as well as radioactive heat is included, unless the earth has expanded its radius by 200 kilometers, due to the more compressible silicate moving from higher to lower pressure regions and the less compressible iron moving in the reverse sense." He believes that the core has been formed during geological time and, in fact, that it is still growing.

Dr. Urey finds that substantial bodies, up to about 100 kilometers in radius, were accumulated during the low temperature stage that followed a higher temperature period in the evolution of the terrestrial planets from a gaseous cold nebula containing dust. Gravitational energy could not have heated the meteorites (fragments from a nebula that did not quite produce a planet) to high temperatures, and hence they were heated from the exterior by the contracting gases of the nebula. His conclusions are the same as those required to preserve water, nitrogen, mercury, and carbon on the earth while the inert gases have been lost.

Norman L. Bowen, of the Geophysical Laboratory, encountered a "petrologic-cosmogonic dilemma" when he assumed the familiar hypothesis that meteorites are fragments of a disrupted planet and that the earth is therefore probably made up of material corresponding with meteoritic matter. But if the earth as a whole really had as high a content of alkalis and aluminum as the meteorite average, we would probably have a universal granitic shell on the earth of very considerable thickness. Petrology and seismology, however, indicate a localized granitic shell of only moderate thickness, supported by basaltic and dunitic material at moderate depth. The difficulty of disposing of the heat of the several kinds of atomic disintegration for such an earth is very much less than that for an earth of meteoritic composition.

Current geologic age measurements by lead, helium, and strontium ratios suggest that the North American continent grew as a result of a succession of land-building periods that began at least as far back as 2.4 billion years, according to P. M. Hurley, of Massachusetts Institute of Technology. William W. Rubey, of the U. S. Geological Survey, pointed out that the relative amounts of the more volatile constituents of the earth's atmosphere — water, carbon, chlorine, nitrogen, and sulphur — indicate that the ocean and the atmosphere may have formed by the escape of such gases from volcanoes and hot springs. The earth may never have been completely molten, and the hydrosphere and atmosphere may have accumulated by gradual escape from the interior. The volume of sea water seems to be increasing, as there is a growing contrast between continental land masses and ocean basins, the latter progressively sinking.

During the origin of the solar system, according to Dr. G. P. Kuiper, of the University of Chicago, distance to the sun was less important to the ultimate composition of a planet than the precise mass of its parent or "protoplanet." The earth differs greatly in composition and mass from Jupiter, not because it was closer to the sun but because proto-Earth was about four times less massive. Proto-Earth appears to have been about 1,200 times the earth's present mass; proto-Jupiter about 12 times Jupiter. Solar tidal friction is believed responsible for the present direct rotations of the planets.

In the pre-planetary gas cloud, large-scale turbulence would lead in some cases to gravitational formation of the protoplanets. These would together sweep up the entire volume previously occupied by the pre-planetary cloud. Dr. Kuiper finds, however, that the outer

(Continued on page 16)

Sky and TELESCOPE

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CONTENTS

NOVEMBER, 1950

COVER: The 200-inch telescope seen from the east side of the mounting. Note the aluminizing tank on the far side of the floor in the lower right. Mount Wilson and Palomar Observatories photograph.

WEIGHING LARGE METEORITES—C. C. Wylie 3
BETA CANIS MAJORIS—The Skeleton in the Closet of Astrophysics —Otto Struve 5
ATLAS OF THE HEAVENS NOTES AND CORRECTIONS 8
ECLIPSE HEADLINES 11

Amateur Astronomers 16
Books and the Sky 14
Gleanings for ATM's 17
News Notes 10
Observer's Page 20
Planetarium Notes 22
Stars for November 23
Terminology Talks 9

BACK COVER: The planet Jupiter, photographed August 8, 1939, by E. C. Slipher, with the 24-inch refractor of Lowell Observatory, Flagstaff, Ariz. The bright and dark belts in the planet's atmosphere are parallel to its equator. The equatorial bulge caused by Jupiter's rapid rotation is easily seen; its equatorial diameter is 88,700 miles. Lowell Observatory photograph.

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The world's largest known meteorite, discovered late in 1920 on the Hoba West farm about 12 miles west of Grootfontein, Southwest Africa, at approximately 19° 35′ south, 17° 56′ east. It is about 83 per cent iron, 16½ per cent nickel, and ¾ per cent cobalt, an ataxite showing no Widmanstaetten structure. This picture was taken in 1929 by W. J. Luyten, now of the University of Minnesota.

WEIGHING LARGE METEORITES*

BY C. C. WYLIE, *State University of Iowa*

ASTRONOMERS studying the fall of meteors and meteorites need their masses, or weights, as well as the dimensions, but for many of the largest meteorites the weights are uncertain since they have not been weighed. A simple rule for calculating the weight from the size is desirable.

The weight of an iron meteorite is approximately 500 pounds, or a quarter of a ton, per cubic foot. Hence, if the weight is expressed in tons and the volume in cubic feet, the weight is equal to one fourth of the volume. This relation holds for any shape, but can be greatly simplified for certain figures. For an iron sphere, the weight is ¼ of $4/3\,\pi\,r^3$, or approximately r^3, where r is the radius and π is considered roughly equal to 3.

The formula for the volume of an ellipsoid whose semimajor axes are a, b, and c, is $4/3\,\pi\,abc$. The weight of an ellipsoidal meteorite in tons is thus one fourth of this, or abc, again considering π roughly equal to 3. For the half ellipsoid, cut perpendicular to the a axis, the new semimajor axis may be called a', and the weight is $a'bc$. This puts the expression for weight in the same form as that for the complete ellipsoid, that is, the product of the three semimajor axes of the solid. The hemisphere is a special case of the half ellipsoid.

Consider now a cone whose major dimensions are for its base $2b$ and $2c$, and for its altitude $2a'$, all dimensions in feet. The weight in tons is $(¼)\ (2a'/3)\ (\pi bc)$, or approximately $a'bc/2$. The weight of a cone is just half that of a half ellipsoid with the same principal dimensions.

Let us now apply these formulas to

In September, 1929, the Grootfontein meteorite was measured by L. J. Spencer, of the British Museum of Natural History, second from left in this photo by W. T. Gordon.

*The substance of a paper by the author presented before Section D, American Association for the Advancement of Science, New York, December, 1949.

the big Grootfontein, or Hoba West, meteorite. Spencer measured the big block in centimeters.[1] Reduced to feet, the dimensions become approximately 10 x 9 x 3 feet. The mass of iron is separated from the limestone in which it is embedded by a layer of "iron shale" 30 centimeters, or about one foot, thick. Spencer assumes that this "represents the amount of weathering that the mass has undergone since it has lain in the ground."

Spencer also states that the big meteorite is approximately rectangular in shape, and, assuming a specific gravity of 7.96, he finds a present weight of 60 metric tons, or 66 tons of 2,000 pounds each. He assumes that the thickness of the "iron shale" perhaps "indicates the original size of the mass" and he states, "adding 30 cm. all round, an original weight of 88 tons would be indicated."

By our formula the weight is ¼ (10 x 9 x 3) or 67½ tons, which agrees satisfactorily with Spencer's figure of 66 tons. Assume with Spencer that the thickness of the iron shale represents the amount of weathering that the big meteorite has undergone since its fall thousands of years ago. There is no shale on top now, but it appears the top would have suffered as much loss as the sides or ends. Adding one foot "all round" we have the weight as ¼ (12 x 11 x 5) or 165 tons. This does not agree at all with Spencer's figure of 88 tons, even assuming he means metric tons, equivalent to 97 ordinary tons. Evidently, Spencer made a mistake, or did not add the full 30 centimeters all around.

If we add only the metal now in the shale, neglecting what may have been leached out in solution in thousands of years as well as what has been lost from the top, we would add about one half a foot, since the shale is about 50 per cent metal, to sides, ends, and bottom. The weight would be ¼ (11 x 10 x 3½), equal to 96 ordinary tons. Evidently Spencer's figure is metric tons, and it is not an approximation to the mass at the time of striking, but an approximation to the present weight of the meteorite plus the metal in the surrounding shale. Presumably the weight at the time of striking was much closer to the 165 tons we have computed.

As for the Ahnighito, the big Cape York meteorite now on display in New York's Hayden Planetarium, the correct weight appears to be in some doubt. The "official" figure is 36½ tons,[2] but it evidently was not obtained by an actual weighing. Mere guesses at the weight range from 37 tons to 100 tons. Two calculations from measurements were found, Peary obtaining 73 tons, and Ward 46½ tons.[3] The most careful determination of the weight to which we have found reference is that by Figgins. He made a model of the big meteorite to scale, and from this model determined the volume. This gave him a weight of 66 tons.[4] Unless he made an error in his calculations, the resulting weight could hardly be in error by as much as 10 per cent, yet it differs from the adopted 36½ tons by 45 per cent. It is obvious that either Figgins or the person responsible for the official figure made a serious error.

The Ahnighito has roughly the shape of a half ellipsoid. The dimensions are 11½ x 7½ x 6 feet.[5] Dividing these measurements by 2 to obtain the semi-major axes, and using the formula for the half ellipsoid, we have 5.75 x 3.75 x 3, or 65 tons.

This is in good agreement with the 66 tons obtained by Figgins. The result from this formula cannot be considered as having too much importance, since the assumed shape is only an approximation, but the agreement with Figgins suggests that the adopted value of 36½ tons should be checked. The construction of another model to scale should be a simple matter, and a good check.

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4. J. D. Figgins, *Op. cit.*, p. 139-140.
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After two unsuccessful attempts to move the Ahnighito meteorite from Saviksoah Island, Melville Bay, Greenland, Peary returned in 1897 with a 100-ton and two 30-ton jacks and "ample supplies of railroad iron and great timbers." From the autumn of that year until September, 1904, the meteorite lay on Cob dock of the Brooklyn Navy Yard. This picture, from the American Museum "Journal" of 1905, shows the Ahnighito in the process of removal to the American Museum of Natural History.

Beta Canis Majoris

The Skeleton in the Closet of Astrophysics

By Otto Struve, *University of California, Berkeley*

THE ARABS called it Murzim, the Announcer. But far from announcing to the world its secrets, Beta Canis Majoris has for many years presented a puzzle so intricate and so confusing that few astronomers have ventured to study it. Some months ago, just before my departure from the Yerkes Observatory, I presented a colloquium on the Lick Observatory's monumental work on the spectrum of this star. In the ensuing discussion, Dr. S. Chandrasekhar, who for many years has been in charge of the colloquia, reminded me that in 1941 I had also spoken on Beta Canis Majoris — "the skeleton in the closet of astrophysics." It was gratifying to conclude that in the past decade at least a few of the problems of this star have been solved.

The story is a rather remarkable case of astronomical detective work, and some of its details are recounted here for the first time. Because of its great apparent brilliance, W. W. Campbell had placed the star upon the original program of observations with the Mills spectrograph attached to the 36-inch refractor. The spectrum turned out to be of the Orion class, or type *B*1, as we now call it, and the spectral absorption lines were unusually sharp and distinct. According to our present criteria of spectral classification we should describe it as a giant, or perhaps even a supergiant star, with a visual absolute magnitude of the order of −5, or about 10,000 times the intrinsic luminosity of the sun.

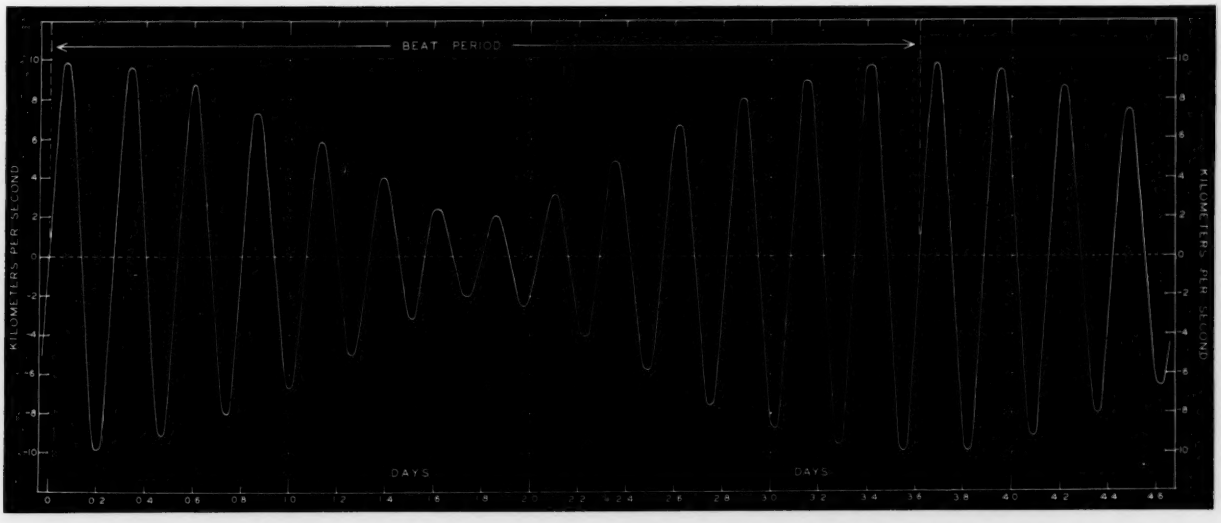
In 1908, S. Albrecht found from the measurements of a few spectrograms that the absorption lines are not fixed in the spectrum, but vary in position. Hence, from the change in the Doppler displacements of the lines, he concluded that the star is one of variable radial velocity, *perhaps* a spectroscopic binary. Two years later, he found the period of this variation in radial motion to be 0.25 day or about six hours. The extreme shortness of this period, rivaled only by those of Beta Cephei (4.6 hours), 12 Lacertae (4.6 hours), and Sigma Scorpii (5.9 hours), immediately placed Murzim among the most interesting of all known "spectroscopic binaries."

As the stars of a spectroscopic binary revolve around each other, they alternately approach and recede from us, producing motions in the line of sight that are revealed by Doppler shifts in their spectral lines alternately toward the red and the violet (recession and approach, respectively). Unfortunately, however, from the spectral observations alone the inclination of the orbit to the plane of the sky, known as *i*, cannot be determined, and we are unable to tell the exact size of the actual orbit. It may be a large orbit with *i* nearly zero, lying almost in the plane of the sky, or a much smaller orbit lying nearly in the line of sight (*i* nearly 90°).

For Beta Canis Majoris, a determination of the orbit was attempted, and the small value of 30,000 kilometers was found for the projection upon the line of sight of the semimajor axis of the elliptical orbit described by the brighter component of the binary around the center of gravity of the pair. This was, indeed, a surprise, because the radius of the *B* star itself must be several hundred times larger than 30,000 kilometers. Thus, if the orbit plane were in or near the line of sight, the center of gravity of the system would be located within the *B* star itself. Of course, it is possible that the orbit is so oriented that the inclination to the plane of the sky is very nearly 0°. Then the actual semimajor axis can be many times larger than 30,000 kilometers. (See the sketch on the next page.)

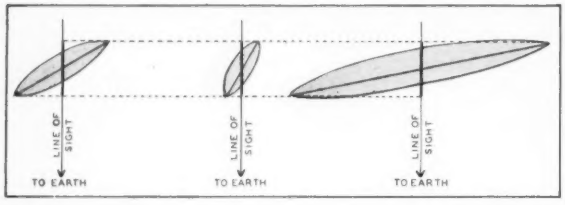
But as other stars of similar spectroscopic properties were investigated, it was found that for all of them the minimum value of the semimajor axis (its projection on the line of sight) appeared close to 30,000 kilometers. As probably not all of these orbits are oriented at right angles to the line of sight, the case of Beta Canis Majoris could not be taken as radically different from the others, and its center of gravity had to be assumed as really quite close to the center of the *B* star. The situation was analogous to that of the sun-earth system, the mass of the hypothetical companion of Beta Canis Majoris being assumed to be quite small compared to that of the primary component of the system.

This conclusion appeared improbable when it was first seriously considered, and gradually astronomers began to regard with suspicion the entire idea of a binary system. At about this time, Shapley, Eddington, and others ad-



A typical radial velocity curve representing the combination of two harmonic oscillations, one having a period of 0.28 day, the other of 0.26 day. The amplitudes of the two individual sine curves were taken to be those of Beta Canis Majoris, 12 and eight kilometers per second, the smaller with the longer period. In this hypothetical case, the beat period is approximately 3.6 days, and there are approximately 14 cycles. In the real case of Beta Canis Majoris the two periods are much more alike; consequently, the beat period is longer, 49 days, and there are correspondingly more cycles.

vanced the theory of radial pulsations — periodic expansions and contractions — to account for the Cepheid variables, and it seemed natural to try this explanation for the Beta Canis Majoris stars. In 1913, P. Guthnick discovered that Beta Cephei varies in light, and a few years later J. Stebbins found small but definitely periodic variations in 12 Lacertae and Sigma Scorpii. In 1935, E. A. Fath announced a similar variation in Beta Canis Majoris. Thus, for all four of the strange stars mentioned above, variations in brightness have been found. These results all indicate an intrinsic type of light variation, not the kind of light changes produced in those spectroscopic binaries that are also eclipsing binaries. For these four stars there are no eclipses!



Spectrographic observations alone cannot determine the inclination of a binary orbit. For instance, these three schematic orbits have very differing actual sizes, but their projections on the line of sight are the same.

What appeared to be the death blow to the binary interpretation came from the spectrographic observations themselves. It became amply apparent that no *ordinary* star could possibly revolve around a *B*-type primary with a period of only six hours. Even with their surfaces in contact, the period would be more nearly like a day or a day and a half.

In recent astronomical literature, these stars are usually referred to as a special group of pulsating variables, akin in some respects to the cluster-type or RR Lyrae Cepheids. But this characterization is often presented grudgingly or in a half-apologetic manner. There are too many differences between the Beta Canis Majoris stars and the typical intrinsic variables of the pulsating kind.

The observation of Beta Canis Majoris in the meantime was being quietly continued at the Lick Observatory. In 1918, F. Henroteau made a sensational discovery in its spectrum, the great significance of which is only now beginning to be appreciated. He found that the absorption lines change in width; sometimes they are sharp and narrow, at other times broad and diffuse. This variation is strictly periodic, in 0.2513015 day or $6^h\ 1^m\ 52^s.45$. Furthermore, Henroteau found that the velocity curve cannot be explained with the help of a single period. The best single value "will not connect all minima of different epochs, but will give either a maximum or minimum of the velocity curve." His later observations at Ottawa tended to obscure, somewhat, the remarkable conclusions reached by him in his work at Lick Observatory.

Partly because of the contradictory results of this later work, the observations were resumed at Lick in 1930, by W. F. Meyer, of the Berkeley astronomical department. Unfortunately, Dr. Meyer in 1942 published only a very brief account of his efforts. Apparently from time to time he had been working on a more extensive paper, but this work was never completed.

Because of the strange conclusions in Henroteau's more recent work, P. Swings and I observed Beta Canis Majoris in 1941 with the coude spectrograph of the McDonald Observatory. Our results confirmed the change in the line widths and agreed approximately, but not completely, with Meyer's short announcement. The remaining discrepancies led to renewed observational work at Lick by Meyer, and at McDonald by Swings and me.

In 1947, I visited the Berkeley campus and had a long discussion with Dr. Meyer and Dr. J. H. Moore, who was much interested in this problem. Meyer's results were extremely impressive and he completely convinced me of the interpretation he had given to the velocity curve. It consists of two strictly periodic oscillations with slightly different periods. The longer, of $6^h\ 1^m\ 52^s.45$, is identical with the period of variation in the line contours, and it has a total amplitude of eight kilometers per second. The shorter, of $6^h\ 0^m\ 1^s.92$, has an amplitude of 12 kilometers per second. The two oscillations combine to give a modulated curve, whose amplitude changes in a beat period of 49 days from a maximum of 20 kilometers per second to a minimum of four kilometers per second. These extremes represent the sum and the difference of the ranges of the two periods. The arithmetical expression defining this relation is:

$$\frac{1}{0.2500222} - \frac{1}{0.2513015} = \frac{1}{49.11}.$$

But there were still some discrepancies between the Lick and the McDonald observations. The latter did not fully bear out the large range in the amplitudes. Meyer decided to observe the star again in the winter of 1947-48. Unfortunately, the McDonald coude spectrograph was then out of operation, since we had decided to rebuild it with a diffraction grating supplied by Johns Hopkins University.

I heard nothing more of Dr. Meyer's work, until in the fall of 1948 word reached us of his sudden death. Because of the importance of the problem, Dr. Moore, director emeritus of the Lick Observatory, took over the accumulated material on Beta Canis Majoris. In an obituary article for Dr. Meyer, he wrote "... he became interested in β Canis Majoris, whose complex variations in radial velocity arise from causes other than orbital motions, and to which he devoted an extended investigation based upon a long series of observations made in different years. Assuming that the observed velocity curve was the resultant of two velocity curves of different amplitudes and slightly different periods, he was able to derive a formula which satisfactorily represented all observations available to him in 1932, and it appeared that at least the first step had been taken toward a solution of the problem. More recent observations, and in particular those of this last year, indicated further complexities; and it was upon these he was working this past summer."

I strongly urged Dr. Moore to finish Meyer's work for publication. He had been intimately connected with the entire project since its very beginning, and Meyer had discussed all its details with him. But, in March, 1949, Dr. Moore suddenly passed away in his sleep — carrying with him what he knew of Beta Canis Majoris.

During the past summer it was my privilege to serve as Morrison research associate at the Lick Observatory. No finer task could present itself to me than the completion of the work of Meyer and Moore. Director C. D. Shane heartily approved of the idea, and I set about trying to find what had already been accomplished.

I found all the measures by Meyer and nearly 700 three-prism spectrograms obtained with the Mills spectrograph. I measured those plates which had not already been measured. The precision of the results is quite in keeping with the high standards set by W. W. Campbell and his successors at Lick. The probable error for one plate is less than one kilometer per second, not bad for an early-type star!

But I found few notes or memoranda. There were some diagrams, partly unmarked, a few tables, two or three letters between Moore and Meyer — and that was all. What they had known about the "complexities" of the star they had carried around in their heads and not recorded on paper. I had to rediscover what they had found before me. Fortunately, what I remembered of our earlier conversations and what I already knew about the star from the McDonald work gave me a start.

It was sometimes necessary to reconstruct what was in Dr. Meyer's mind from an exclamation mark on a diagram or a question mark in a table. At various times he had enlisted the assistance

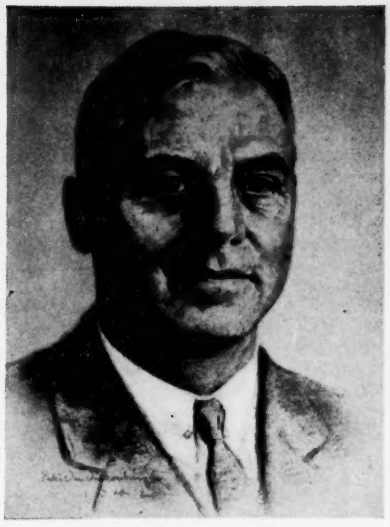
of graduate students at Berkeley, and some of their summaries yielded valuable clues as to where the thoughts of the California investigators had led. One of them, Robert Leonard, had derived convenient formulas for the amplitude and phase shift of the resulting oscillation, composed from the addition of two sine curves of slightly different periods. These formulas were used by Meyer throughout.

The technical details of this work of reconstruction will appear in the *Astrophysical Journal*. The existence of the two periods is confirmed. The shorter remained constant over the entire interval of 44 years covered by the observations; so did the corresponding amplitude of the velocity oscillation. But the longer period changed slightly, as did its amplitude, which was at one time as large as eight kilometers per second, but has more recently been of the order of four kilometers per second.

Meyer had retained a belief in the binary character of Beta Canis Majoris —and in modern dress this idea deserves careful consideration. Suppose that one of the two velocity oscillations is caused by binary motion. But, you will say, what about the objections raised previously? How can the projected size be so small? It can, if the companion is not an ordinary star, but very small and dense. Revolving at the surface of a normal *B* star it would have a period of just about six hours. But what about the absence of eclipses in the light curve? If the companion is a white dwarf, or some strange kind of planet, its projected area would be so small compared to that of the *B*-type primary that we could not detect the eclipses.

The second velocity oscillation must be related to the variation in line width. The lines are broadest when, within its own cycle, the velocity passes through zero, from positive (recession) to negative (approach). This suggests some kind of turbulence on that side of the *B* star which is oriented toward the companion. This secondary variation in velocity and line contour may be in the nature of a vibration which is somehow induced by the companion, whose own orbital period is nearly two minutes shorter. The discerning reader may question why we assign the shorter period to the binary motion and the longer to the vibration. Actually, there is no way to be certain which is which. Some recent observations of another, similar star, suggest that the period of the change in line contour is the period of binary motion.

We have no physical picture of the manner in which these vibrations are produced. But, conceivably, they are analogous to the vibration of a string excited by a tuning fork whose frequency differs but very slightly from one of the overtones of the string.



W. F. Meyer (1880-1948), of the Berkeley astronomical department.

It must be recognized that the more we know about Beta Canis Majoris and Beta Cephei, the less they seem to resemble either ordinary Cepheids or cluster-type variables. This becomes especially apparent when we remember that there are probably two distinct groups of stars which were formerly indiscriminately designated as Beta Canis Majoris objects. The true representatives of this group usually have early spectral types, and reasonably sharp lines. They may include a few objects as late in type as *F* (Delta Scuti), but the majority are *B*'s. Their light variation is intrinsic and may, according to O. J. Eggen, show occasional short "flares." The second group is much less distinct. Its representatives have broad absorption lines, and the suggestion has been advanced that their variations in light and radial velocity may result from bright or dark surface markings on a rapidly rotating star.

Among the members of the first group, with which we are now concerned, there are some stars with marked giant or supergiant characteristics (β Canis Majoris) and others with typical main-sequence spectra (β Cephei, 12 Lacertae, σ Scorpii). Yet, the periods of these objects all range between 4.6 and 6.0 hours. This is quite different from the ordinary Cepheids, which show a strong correlation between period and luminosity (the famous Leavitt-Shapley period-luminosity relation). In mathematical form this relation tells us that the square root of the mean density of a Cepheid variable star is inversely proportional to its period. Thus, if the periods of Beta Canis Majoris and Beta Cephei are 6.0 and 4.6 hours, respectively, we should infer that their densities are $(4.6)^2/(6.0)^2 = 0.6$. Yet, from their spectra we should conclude that the mean density of the former is more nearly 1/10 that of Beta Cephei. This type of reasoning is opposed to the simple pulsation hypothesis as applied to Murzim, but there may be some other more complicated types of pulsation that would reconcile the different points of view.

This suggested return to the old binary hypothesis is quite in keeping with a number of other observations. I am writing this account at Mount Wilson Observatory, where I have just carried on a spectrographic study of another representative of this class of objects, 12 Lacertae. A quick inspection of the plates strongly suggests that the phenomena in this star closely resemble those of Beta Canis Majoris. The change in line widths is almost unbelievably large; and there are indications that the lines vary as we would expect if our picture of a close binary is the correct one.

METEORS FOR METEOROLOGY

As yet only meteors and rare high-flying rockets have been able to yield information on the velocities of winds from 55 to 80 miles above the surface of the earth. Weather balloons have reached only half these heights. The latest advance is to observe meteor trains by radar, and it is found that even where the train lasts for only a second or two its radar echo reveals its drift in the high-altitude winds. L. A. Manning, O. G. Villard, Jr., and A. M. Peterson, of Stanford University, describe this work in the August, 1950, issue of the *Proceedings* of the Institute of Radio Engineers.

NOTICE TO SUBSCRIBERS

Effective with this issue, the subscription price to **Sky and Telescope** is $4.00 per year, $7.00 for two years, for subscribers in the United States and possessions, and in Latin-American countries. For Canada and other foreign countries, add $1.00 per year, making the one-year rate $5.00, and the two-year rate $9.00.

Subscriptions expiring with this issue have been billed at the former rates, but those expiring with the issue of December, 1950, and thereafter will be billed at the new rates. Nevertheless, the increase in rate will not actually apply to present subscribers until January 1, 1951, for before that time subscriptions now in effect may be renewed, regardless of expiration, at the former rates of $3.00 per year in the United States and possessions; $3.50 in the Pan American Postal Union; $4.00 in Canada and all other foreign countries.

Atlas of the Heavens Notes and Corrections

BECVAR'S Skalnate Pleso **Atlas of the Heavens** portrays a large number of celestial objects in a satisfactory way. The explanatory text and keys are ample, so even a beginner should have no difficulty in using the atlas. A few points, however, may be worth mentioning.

The constellations will be easier to find if the names are underlined with a colored pencil. This may be done easily and neatly if a drawing board and T-square are available. Some users of the atlas may wish that star names had been included, but this would cause undue crowding in some places. Any names may be easily written in with a pencil.

The Greek letters that designate the stars are in script, and a few of them, especially theta and kappa, are in an unfamiliar form, at least to the average American amateur. Care should be taken not to confuse the Greek "tau" with the variable star designation "T." An example of this is found in the extreme lower right-hand corner of Chart VII, where the tau's have subscripts. The atlas consistently follows the European style of commas for decimal points.

The atlas presents a storage problem, unless a large shelf or shallow drawer is available. The problem may be satisfactorily solved, however, by using an artist's portfolio, which may be obtained from almost any art supply store for about two or three dollars. A substitute may be made of cardboard, with the outer edges stiffened with strips of wood or metal.

In order to determine the magnitude of a given star in the atlas, it is necessary to compare the star with the corresponding disk in the key. This may be easily done with a device made by ruling two lines on a thin piece of transparent plastic. The lines should form a long narrow V, with the open end at least as wide as the largest disk in the key. The device may be calibrated by laying it on the key and making short marks on the lines at the points of tangency of the various disks. The lines may be made in ink with a fine pen, or scratched with a sharp-pointed instrument. Protect them by cementing another piece of plastic over the first, or by a coat of lacquer.

The boundaries of the Milky Way are designated in the key as "Isophota Galactica," meaning lines of equal brightness, analogous to the isotherms and isobars on a weather map. Since the Milky Way has no sharply defined boundary, the lines merely indicate where the light has diminished to a point which, according to Pannekoek, may be reasonably called a boundary. This procedure is customary on other charts.

Some Latin terms in the key may prove confusing. "Duplices Spectroscopicae" indicates spectroscopic double stars. "Cumuli Galactici" refers to open or galactic clusters, while "Cumuli Globulares" indicates globular clusters. "Nebulae Anagalacticae" refers to galaxies or extragalactic nebulae.

HENRY S. SHAW
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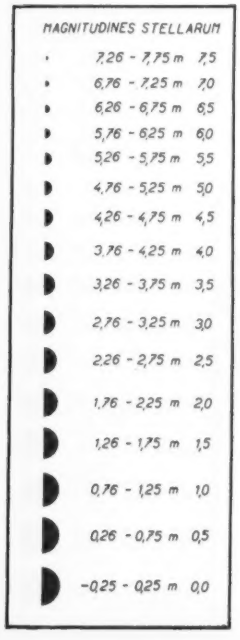
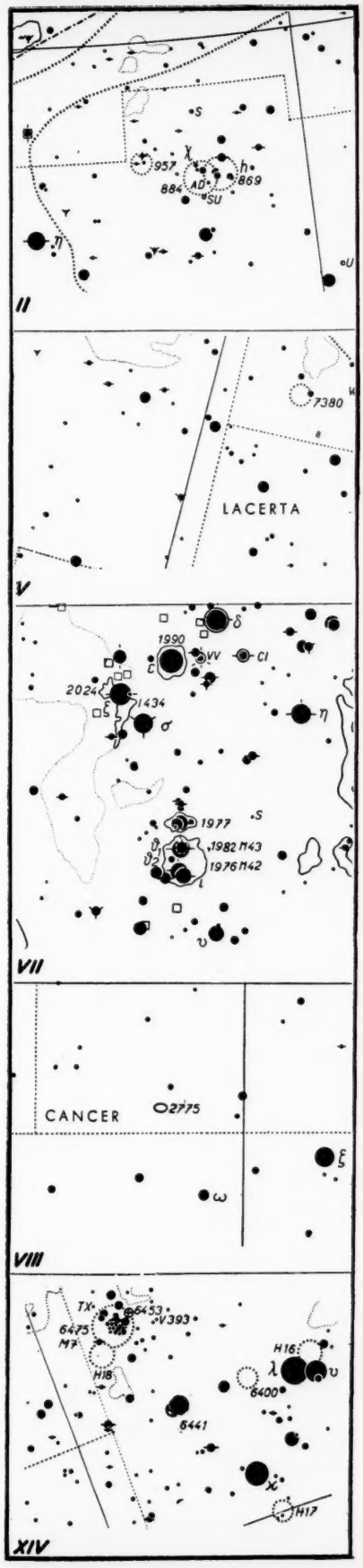


Another method for reading stellar magnitudes off the charts—superimpose the bisected images on the printed star images.

AN INDEX FOR THE ATLAS OF THE HEAVENS

CONSTELLATION	Chart	R.A. Hours & Min.	Dec. Degrees	Chart	R.A. Hours & Min.	Dec. Degrees	Chart	R.A. Hours & Min.	Dec. Degrees
ANDROMEDA	II	22:55 - 2:35	N21 - N53	V	22:55 - 1:05	N28 - N53			
ANTLIA	XIII	9:25 - 11:05	S24 - S40						
APUS	XVI	13:45 - 18:10	S67 - S83						
AQUARIUS	XI	20:35 - 23:55	N 3 - S25	XV	21:55 - 23:55	S14 - S25			
AQUILA	X	18:40 - 20:20	N19 - S12	XI	19:40 - 20:40	N16 - S12			
ARA	XIV	16:30 - 18:05	S46 - S68						
ARIES	VI	1:45 - 3:25	N10 - N25	II	1:45 - 3:25	N19 - N31			
AURIGA	II	4:35 - 6:55	N28 - N56	III	4:45 - 7:30	N28 - N56			
BOOTES	IV	13:30 - 15:50	N16 - N55	IX	13:30 - 15:10	N 7 - N25			
CAELUM	XII	4:20 - 5:05	S27 - S49						
CAMELOPARDALIS	I	3:10 - 14:30	N57 - N86	II	3:10 - 7:40	N52 - N70	III	4:10 - 8:05	N52 - N70
CANCER	III	7:55 - 9:20	N19 - N34	VIII	7:50 - 9:20	N25 - N 6			
CANES VENATICI	IV	12:05 - 14:05	N28 - N53						
CANIS MAJOR	VII	6:10 - 7:25	S11 - S25	XIII	6:10 - 7:25	S14 - S33			
CANIS MINOR	VII	7:05 - 8:10	0 - N13						
CAPRICORNUS	XI	20:05 - 21:55	S 8 - S25	XV	20:05 - 21:55	S19 - S28			
CARINA	XIII	6:00 - 11:20	S51 - S70	XVI	7:00 - 11:20	S56 - S75			
CASSIOPEIA	I	22:55 - 3:35	N53 - N78	II	22:55 - 3:35	N46 - N70	V	22:55 - 1:50	N46 - N66
CENTAURUS	XIII	11:05 - 13:50	S35 - S65	XIV	11:05 - 15:00	S30 - S65			
CEPHEUS	I	20:00 - 8:05	N53 - N88	V	20:00 - 24:00	N53 - N70			
CETUS	VI	23:55 - 3:20	N10 - S25	XII	0:00 - 2:45	S14 - S26			
CHAMAELEON	XVI	7:40 - 13:45	S75 - S83						
CIRCINUS	XIV	13:30 - 15:25	S54 - S70	XVI	13:30 - 15:25	S55 - S71			
COLUMBA	XII	5:05 - 6:40	S27 - S43	XIII	5:10 - 6:40	S27 - S43			
COMA BERENICES	IV	11:55 - 13:35	N14 - N34	IX	11:55 - 13:35	N13 - N25			
CORONA AUSTRALIS	XV	17:50 - 19:15	S37 - S46						
CORONA BOREALIS	IV	15:15 - 16:25	N25 - N40						
CORVUS	IX	11:50 - 12:55	S11 - S25						
CRATER	VIII	10:50 - 11:55	S 6 - S25						
CRUX	XIV	11:50 - 12:55	S55 - S65	XIII	11:50 - 12:55	S55 - S65	XVI	11:50 - 12:55	S55 - S66
CYGNUS	V	19:05 - 22:00	N27 - N61						
DELPHINUS	XI	20:10 - 21:10	N 2 - N21						
DORADO	XII	3:50 - 6:40	S48 - S69	XVI	4:30 - 6:35	S63 - S70			
DRACO	I	9:15 - 20:45	N55 - N86	IV	12:00 - 19:50	N47 - N70	V	16:10 - 20:40	N47 - N70
EQUULEUS	XI	20:55 - 21:25	N 2 - N13						
ERIDANUS	VI	2:40 - 4:20	0 - S25	VII	3:40 - 5:10	0 - S25	XII	1:20 - 4:55	S17 - S58
FORNAX	XII	1:45 - 3:50	S24 - S40						
GEMINI	III	5:55 - 8:05	N14 - N36	VII	5:55 - 7:55	N10 - N25			
GRUS	XV	21:25 - 23:25	S36 - S57						
HERCULES	IV	15:45 - 18:15	N14 - N51	V	16:40 - 18:55	N14 - N51	X	15:55 - 18:55	N 4 - N25
HOROLOGIUM	XII	2:10 - 4:20	S40 - S67						
HYDRA	VIII	6:05 - 10:55	N 7 - S25	XIII	9:10 - 12:20	S17 - S35	XIV	11:35 - 15:00	S22 - S36
HYDRUS	XII	1:20 - 4:35	S58 - S70	XVI	0:00 - 4:35	S58 - S82			
INDUS	XV	20:25 - 23:25	S45 - S70	XVI	20:25 - 23:25	S49 - S75			
LACERTA	V	21:55 - 22:55	N35 - N57						
LEO	III	9:20 - 11:55	N14 - N34	VIII	9:20 - 11:55	N25 - S 7			
LEO MINOR	III	9:20 - 11:05	N23 - N42						
LEPUS	VII	4:55 - 6:10	S11 - S25	XII	4:45 - 6:05	S14 - S27			
LIBRA	IX	14:20 - 16:00	S - S25	XIV	14:20 - 16:00	S19 - S30			
LUPUS	XIV	14:15 - 16:05	S30 - S55						
LYNX	III	6:10 - 9:40	N33 - N62						
LYRA	V	18:10 - 19:30	N25 - N48						
MENSA	XVI	3:35 - 7:40	S70 - S85						
MICROSCOPIUM	XV	20:25 - 21:25	S27 - S46						
MONOCEROS	VII	5:50 - 8:10	N12 - S11						
MUSCA	XVI	11:15 - 13:45	S64 - S75						
NORMA	XIV	15:25 - 16:30	S42 - S61						
OCTANS	XVI	0:00 - 24:00	S74 - S90						
OPHIUCHUS	X	16:00 - 18:45	N14 - S25	XIV	16:20 - 17:40	S16 - S30			
ORION	VII	4:40 - 6:25	N23 - S11						
PAVO	XV	17:40 - 21:30	S57 - S70	XVI	17:40 - 21:30	S59 - S75			
PEGASUS	V	21:15 - 0:10	N14 - N36	XI	21:05 - 0:15	N 2 - N25			
PERSEUS	II	1:25 - 4:50	N31 - N59						
PHOENIX	XII	23:20 - 2:25	S40 - S58	XV	23:20 - 1:25	S40 - S51			
PICTOR	XII	4:30 - 6:50	S43 - S64	XIII	4:30 - 6:55	S43 - S64			
PISCES	II	0:10 - 1:45	N14 - N34	VI	23:40 - 2:05	N25 - S 7	XI	22:50 - 0:20	N21 - S 7
PISCIS AUSTRINUS	XV	21:25 - 23:05	S25 - S37						
PUPPIS	VII	7:25 - 8:20	S11 - S25	VIII	7:40 - 8:25	S11 - S25	XIII	6:00 - 8:35	S18 - S51
PYXIS	VIII	8:25 - 9:25	S17 - S25	XIII	8:25 - 9:25	S20 - S37			
RETICULUM	XII	3:15 - 4:35	S63 - S67						
SAGITTA	X	18:55 - 20:20	N16 - N22						
SAGITTARIUS	X	17:40 - 20:05	S12 - S25	XIV	17:40 - 18:30	S16 - S37	XV	17:45 - 20:25	S16 - S46
SCORPIUS	X	15:45 - 16:30	S 8 - S25	XIV	15:45 - 17:55	S16 - S46			
SCULPTOR	XII	23:25 - 1:45	S25 - S40	XV	23:05 - 0:40	S25 - S40			
SCUTUM	X	18:15 - 18:55	S 4 - S16						
SERPENS CAUDA	X	17:15 - 18:55	N 7 - S16						
SERPENS CAPUT	IV	15:10 - 16:05	N20 - N26	IX	15:10 - 16:20	N25 - S 4			
SEXTANS	VIII	9:40 - 10:50	N 7 - S11						
TAURUS	II	3:25 - 6:00	N14 - N31	VI	3:20 - 4:20	N25 - S 2	VII	3:40 - 6:00	0 - N25
TELESCOPIUM	XV	18:05 - 20:25	S45 - S57						
TRIANGULUM	II	1:30 - 2:50	N25 - N37						
TRIANGULUM AUSTRALE	XVI	14:50 - 17:10	S60 - S71	XIV	14:50 - 17:10	S60 - S70			
TUCANA	XVI	22:05 - 1:20	S56 - S76						
URSA MAJOR	I	8:05 - 14:30	N47 - N73	III	8:05 - 18:50	N29 - N70	IV	10:10 - 14:30	N29 - N66
URSA MINOR	I	0:00 - 24:00	N65 - N90						
VELA	XIII	8:00 - 11:05	S37 - S57						
VIRGO	VIII	11:35 - 15:20	N14 - S11	IX	11:40 - 15:10	N15 - S23			
VOLANS	XVI	6:35 - 9:05	S64 - S75						
VULPECULA	V	18:55 - 21:30	N19 - N29	XI	19:40 - 21:30	N19 - N25			

Prepared by Charles E. Kratz, of Baltimore, Md., this index is accurate approximately to the nearest degree, and it does not include small or minor areas of a constellation that are duplicated in other references given.



CORRECTIONS FOR THE SKALNATE PLESO ATLAS

SINCE the Skalnate Pleso **Atlas of the Heavens** was introduced in 1948 (see **Sky and Telescope,** November, 1948, page 13), several errors have been reported. Corrected sections of the charts concerned are printed here, and may be mounted or copied on the charts.

Chart II. The identifications for the Double Cluster in Perseus are reversed: the "h" should read "χ" and conversely.

Chart V. A 7th-magnitude star in the constellation of Cassiopeia, near the Cepheus-Lacerta boundary, at 23h 02m, +56° 10′, should be removed.

Chart VII. The nebulosity in Orion labeled "1982, M43" should read "1977," and the upper part of the Great Nebula marked "1976, M42" should bear the label "1982, M43." This error was noted in June, 1949, on page 203 of **Sky and Telescope.**

Chart VIII. Near the southern boundary of Cancer, the galaxy numbered "2275" should read "2775."

Chart XIV. A 3rd-magnitude star, G Scorpii, should be inserted slightly northwest of the center of NGC 6441, the star symbol obliterating part of the symbol for the globular cluster.

We are indebted to many readers and chart users for these corrections, among them Robert Adams, George A. Davis, Jr., Simone Daro Gossner, N. Assis Ribeiro, Henry S. Shaw, and Campbell Wade. Other errors in the **Atlas of the Heavens** should be reported for similar publication.

TERMINOLOGY TALKS

J. HUGH PRUETT

"AND the evening and the morning were the first day." In whatever way we may interpret these words of the ancient Hebrew writer, they surely state in simple language the concept of our smallest natural unit of time, a cycle made up of a period of darkness followed by one of light. The real cause of the cycle was not originally understood, but the effect was quite evident.

Evening and Morning

These terms are variously used, even today. Some think of a day as made up of morning, afternoon, evening, and night. Others, starting at midnight, may list only the first three. Some few include all the afternoon up to bedtime as evening. But the writer of the book of Genesis may have had in mind the meaning given in an old edition of the *Encyclopaedia Britannica,* which states, "a day is made up of 12 morning hours from midnight to midday and 12 evening hours from midday to midnight."

Some of the ancient nations considered a new day had its beginning at sunrise. Others started the day at sunset. At present, both civil and astronomical days begin at midnight. Before January 1, 1925, the astronomical day started at noon, 12 hours after the civil day, so that telescopic work running across midnight would not have to be listed under two dates. For the past quarter century, however, nautical almanacs have used the civil day exclusively, although some observatories still use the old astronomical day in their records.

Apparent Solar Day

Since old Sol is the most conspicuous of all the celestial bodies, it is quite natural that we should count time from his positions. The noon point finds him highest in the heavens and easy to observe. *Apparent noon* is the time the sun's center is at the upper crossing of the celestial meridian. This is indicated most simply by a properly installed and graduated sundial. An *apparent solar day* is the interval between two successive noon positions. With no time-measuring instruments more accurate than a sundial — and nothing more was needed by primitive peoples — it would make no difference to know that the length of the solar day varies somewhat.

In ancient times, it was generally believed that the solar day was determined by the complete revolution of the sun around our humble earth. Now we know that such a day is the time required — nearly, but not quite — for the world to make a complete rotation on its axis.

The sun's apparent eastward motion among the stars, about one degree per day, is the "reflection" of the actual revolution of the earth around the sun. When we are nearest the sun (in January) the earth moves faster on its elliptical orbit than when we are more distant. This causes the sun to go eastward faster than at other times, and thus to delay more than normal its daily arrival at the noon position. Another cause of delay is that the sun moves eastward along the ecliptic rather than along the celestial equator. The two circles are inclined at an angle of 23½° to each other. When the sun is on the "uphill" or "downhill" part of the ecliptic (around the times of the equinoxes), it does not move eastward as rapidly as at the times of the solstices — especially the winter solstice — when it moves parallel to the equator.

As a result of these complications, successive intervals between two meridian crossings may at times vary from a precise "clock day" by as much as nearly 30 seconds. And the difference between the longest and shortest solar days amounts to 51 seconds.

NEWS NOTES

By Dorrit Hoffleit

A STELLAR ENCOUNTER?

At Radcliffe Observatory, Dr. David S. Evans has photographed the peculiar planetary nebula IC 4406 with the 74-inch reflector, and in the *Monthly Notices* of the Royal Astronomical Society (Vol. 110, No. 1) he speculates on the nature of this strange system. The nebula is strongly elongated in the east-west direction and the ends are slightly concave. One associated star appears centered on the nebula, and another is some 33 seconds of arc to the west of the center. Near this second star the nebula shows shell structure, with "an asymmetrical tongue of brightness, issuing from the nebula and running close round the star to the southwest of it."

If this system is old enough to be in equilibrium, we would expect on most hypotheses to find the center of the nebula between the two stars, not centered on one of them. Dr. Evans suggests that this may be a relatively young association such as would occur if the central star of a planetary nebula encountered a second star in its journey through space. The second star would set up tidal effects in the nebula that would be ellipsoidally symmetric around the central star, and the observations seem to give some indication of this situation for IC 4406 at present.

MORE ON SEEING

At the Salt Lake City meeting of the Astronomical Society of the Pacific in June, Dr. Fritz Zwicky, of Mount Wilson and Palomar Observatories, described further experiments for analyzing seeing, prompted by the recent work of Gaviola (reviewed in *Sky and Telescope* this January and February). Using an 18-inch mosaic Wood grating with the Palomar 18-inch Schmidt, Dr. Zwicky obtained spectra of bright stars trailed at right angles to their dispersion. Some were trailed at the sidereal rate; for others the telescope was swung at about 10 degrees a second.

These photographs show that really instantaneous star images are never white, fluctuating greatly in color as well as in total brightness. At any narrow wave length band, the brightness may change by several magnitudes within a small fraction of a second. In a 1/1,000-second exposure of Sirius trailed over 4.53 millimeters, four very pronounced minima and over 10 light cycles are seen. Such pictures always reveal "hard" seeing (dancing images), even when simultaneous visual observations indicate "soft" seeing (blurred images).

In the trailed spectra, Dr. Zwicky found that the apparent wave length interval between any two lines was not constant, varying by as much as 16 angstroms between the hydrogen-gamma and hydrogen-delta lines. Such displacements would correspond to radial velocities of 2,000 kilometers a second at the light source. Just how well do these differences average out on standard radial-velocity plates?

The complete text and photographic examples of Dr. Zwicky's observation appear in the August *Publications* of the Astronomical Society of the Pacific.

AN UNUSUAL DISCOVERY

At the Leander McCormick Observatory, Dr. A. N. Vyssotsky noticed on an objective-prism plate that the density of one star's spectrum changed in the direction in which the image was trailed to widen the spectra. Thereupon, A. D. Code examined the star with a photoelectric photometer and found it to vary by 0.6 magnitude in a period of only 127 minutes. It is the 10th-magnitude star BD −0° 2911, the brightest cluster-type variable with a period of less than 1/10 of a day. The shortest period for such a variable is 88 minutes, for CY Aquarii.

EARTH MODEL

A model of the earth based on the assumption that the chemical composition throughout is roughly uniform — chiefly oxygen, iron, magnesium, and silicon — has been proposed by a British scientist, W. H. Ramsey, and is described popularly in the August issue of *Science Digest* by Sydney Cooper.

If the earth has an iron core, as has long been assumed, why do not iron meteorites reveal as high a percentage of iron as would be required, and how can the iron core account for the earth's magnetism with temperatures at the center so high that any iron must be rendered nonmagnetic? Why is there a sharp discontinuity between the mantle and the core?

Ramsey finds that at about 1,800 miles below the surface of the earth the pressure amounts to about 1.4 million atmospheres and normal atomic structure breaks down, allowing the atoms to crowd together more closely. Rocks with normal densities of 5.8 times that of water suddenly behave like metals with densities around 9.6, and explain the well-observed reflections of earthquake waves from various layers inside the earth. By extreme pressure even hydrogen can be turned from compressed gas into a metal resembling sodium with a density three fourths that of water. Pressures at the earth's center are probably 50 million pounds per square inch, and temperatures are estimated at between 20,000° and 55,000° Fahrenheit.

DOUBLE STAR 31 CYGNI

In his address as retiring president of the Rittenhouse Astronomical Society, Dr. Raymond H. Wilson, Jr., of Temple University, outlined the history of stellar interferometry and presented some of his own research results. When, last summer, he turned his interferometer on 31 Cygni, the star was shown to be double with a separation of only 0.06 second of arc. This is much too close for the star to be directly observed as a double, even with the largest telescope. Later, Dr. Wilson discovered that the star was already known as a spectroscopic binary: Julie M. Vinter Hansen in 1944 had determined from spectroscopic data that the components revolve about one another in a period of about 10 years, and she predicted just about the separation found with the interferometer. This gratifying confirmation suggests that interferometer observations of many a spectroscopic binary may prove fruitful.

BRITISH INTERPLANETARY SOCIETY

Among the lectures scheduled before the British Interplanetary Society this season are several open to visitors and of interest to amateur astronomers, including a symposium on the orbital rocket on January 6th; "Interplanetary Orbits," by J. G. Porter, president of the British Astronomical Association, February 3rd; "The Evolution of Life in the Universe," by J. D. Bernal, on April 7th. These meetings are at 6 p.m., in the Tudor room, Caxton Hall, Westminster, London.

In the CURRENT JOURNALS

THE AGE OF SCIENCE, 1900-1950, **Scientific American,** September, 1950. This is a series of articles by 10 leading scientists in as many different fields, with an introduction by J. R. Oppenheimer. "The citizen who wants to understand what science has done and where it is going needs an over-all picture of the main outlines of the scientist's findings."

THE CHALLENGE OF THE RULED GRATING, by George R. Harrison, **Physics Today,** September, 1950. "Few problems of experimental physics have a more colorful background than that involved in the ruling of large diffraction gratings. Nor is any problem of such great importance more widely misunderstood."

SPERRY'S SPINNING GUIDEPOST, by James E. Payne, **Steelways,** September, 1950. "A gyroscopic conscience keeps ships, planes and rockets on the straight and narrow . . . an extraordinary story of inventive genius, persistence, and steel."

Here's How The Moon Looked To Akronites

HERE IS HOW THE HARVEST MOON WAS GRADUALLY BLACKED OUT BY THE EARTH'S SHADOW DURING THE TOTAL ECLIPSE MONDAY NIGHT —PHOTOS BY EUSTACE STIVAS

EXT SUNDAY'S MAGAZINE ROTOPIX

AKRON BEACON JOURNAL

FINAL EDITION

Ohio's Most Complete Newspaper

NO. 294 | 111th Year | Tuesday, September 26, 1950 | ★★★★ | 52 Pages | Four Cents

Astronomy Club Gives Observing Party

For those who wanted to go a little further than watching the moon's eclipse with the d eye, there were telescopes available Monday night at an observing party at the Goodyear Range on Gilchrist rd. The party was sponsored by the Astronomy Club of Akron. This is t of the crowd.

ONLY 24 MILES BETWEEN FRONTS

Allies Mor Reds F

WHAT OHIO THINKS

Bromfield For Taft, Lausche

By RAY C. SUTLIFF

MANSFIELD—In a restless world that's only one jump ahead of atomic jitters most of the time, it's comforting to ride through the rolling Richland County hills and absorb some of the feeling of the farmers that maybe things aren't as black as they look.

Gang

and Jury tion Next r Major

Sky Opens Up To Give Clear View Of Eclipse

Precise Universe Stages Big Lunar Show Exactly As Billed

By KEITH SPRAGUE

THIS PART OF THE EARTH was moonstruck Monday night. Things were looking up more in the Akron district than they have for a long time.

If there is more than the usual crop of cricket necks this morning, it's because of the "Blackouts of 1950" staged by the man in the moon Monday night.

CHEST AGENCIES

Stranded, Boys Get Aid, Jobs

Eclipse photographs taken at 15-minute intervals by Eustace Stivas, a member of the Akron Astronomy Club, were featured in this Akron newspaper, along with a story of the eclipse party.

ECLIPSE HEADLINES

CONDITIONS were generally favorable for the eclipse of the moon in September, with the Northwest clouded out and the smoke pall affecting observations in relatively limited areas. The eclipse proceeded on schedule, and the moon during totality appeared a light orange copper color, not nearly as "dark" as during the eclipse of a year ago.

The Astronomy Club of Akron held a successful public observing party, operating 10 telescopes all made by members of the club. The night was beautifully clear. The reproduction from the Akron paper the next day was sent by Mrs. R. J. Couts, secretary of the society.

At Goshen College, Ind., Owen Gingerich had an observing group of 100 students. He used a five-cell flashlight to point out constellations. On the previous day, Sunday, September 24th, the smoke pall turned the sun to a distinct blue or violet.

In Pittsburgh, crowds thronged Allegheny Observatory and the Buhl Planetarium, where all manner of telescopes were made available. Similar parties were held at other planetariums. In Boston, where the smoke pall did not arrive until the evening of the eclipse, some 1,500 persons observed with telescopes set up at the Boston Museum of Science, Science Park, by members of the Amateur Telescope Makers of Boston. A loudspeaker was used by several guest astronomers, including Dr. Armin J. Deutsch, of Harvard Observatory, and Dr. Eric Lindsay, of Armagh Observatory in North Ireland. The eclipse party at New York's Hayden Planetarium was spoiled by thickening of the smoke pall. At Rochester, N.Y., the eclipse was clouded out.

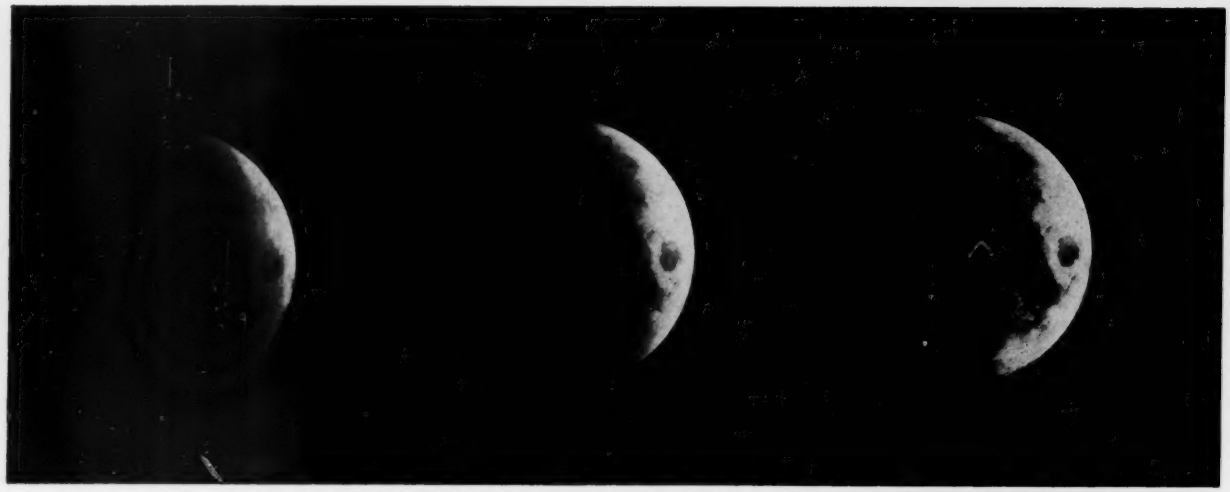
In Atlanta, Ga., about 30 members of the local society gathered at the home of Mr. and Mrs. W. H. Close, armed with seven instruments ranging in size from two to 12 inches. The sky was perfect, but the night was chilly. P. O. Parker, secretary of the group, noted that for the first few minutes after first contact the shadow appeared dark, almost black, but it soon took on a copper-red color except at the northwest limb; there it remained white or gray throughout the total phase. To him it was only a moderately dark eclipse, the more prominent features of the moon's surface being visible at all times.

At Dallas, Tex., the partially eclipsed moon was seen for a few minutes as it broke through clouds at nine o'clock (CST). E. M. Brewer, president of the Texas Astronomical Society, writes that a filmstrip, "Our Changing Moon," was shown while the real eclipse was invisible. Clouds obscured the moon throughout totality.

From Norton Air Force Base, San Bernardino, Calif., Staff Sergeant R. G. McArthur observed the eclipse in its entirety, with perfect weather, and found it to be a much lighter eclipse than last October's. He is a member of the Kansas City Amateur Astronomers and Telescope Makers on active duty with the Air Force.

At the Griffith Observatory and Planetarium, telescopes for the public were set up on the observatory roof and grounds, but the 12-inch observatory instrument was reserved for newspaper photographers, with Paul Roques in charge, according to Los Angeles press accounts. Los Angeles had a fine, early evening eclipse.

At Montreal, the members of the Royal Astronomical Society of Canada



Indiana University students took these eclipse photographs with the 12-inch refractor of Kirkwood Observatory, with yellow-sensitive film and filter. The left-hand picture is 19 minutes before totality.

did their observing according to instructions from the Association of Lunar and Planetary Observers. The program included recording of color changes, timing of the contacts, and search for lunar meteors during totality.

Carl B. Johnson, at North Easton, Mass., followed the instructions for photographing the eclipse given by Peter A. Leavens in the September issue of *Sky and Telescope*. He felt that the wide range of exposures recommended would not fit with the actual progress of the eclipse, in that the intensity of the bright part of the moon should not decrease very much until just before totality.

Nevertheless, he followed the recommended exposure table, for the seven principal phases of the eclipse, as closely as the f/ scale on his Rollei camera would permit. With Eastman Plus-X, developed in D-76, he procured a very creditable series of pictures. He believes his negatives to be somewhat overexposed in the narrower phases.

In the foothills of the Ozarks, at Neosho, Mo., Robert M. Adams observed through clear skies, but with occasional altocumulus clouds partially obscuring the moon and adding to the beauty of the phenomenon. Totality seemed dark, with the Milky Way visible, and a 14.5-magnitude variable star was observed with a 10-inch reflector. Mr. Adams made a drawing to show a deep shadow that cut across the southeast portion of the moon just before totality. This shadow was very marked to the naked eye, but scarcely noticeable at 30x in a 2-inch refractor and not observable in the 10-inch reflector.

Photoelectric Measures of the Eclipse

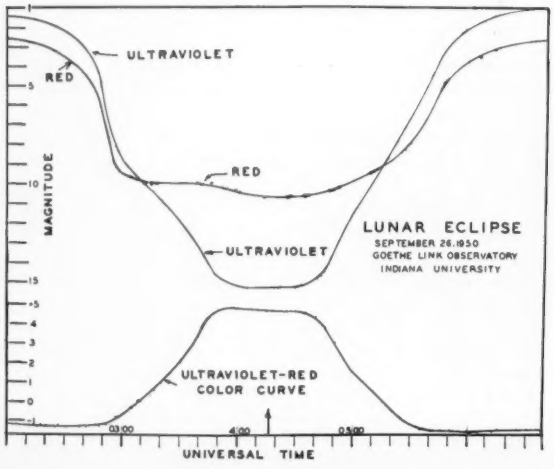
LADY LUCK smiled on Indiana on the night of September 25-26. The blanket of smoke clouds from the forest fires in Canada, which for the previous few nights had threatened to prevent our seeing the eclipse, disappeared entirely, and perfect skies prevailed throughout the event. The visual spectacle was impressive and colorful, as the moon strode through the earth's sunset-colored shadow.

The photoelectric observations made by Don M. Bubeck and the writer with the 36-inch reflector at the Goethe Link Observatory give quantitative information of the changes in the color and brightness of the lunar crater Tycho, located on the side of the moon that passed nearer to the center of the earth's shadow than did the center of the moon as a whole. The photoelectric equipment included a 1P21 photomultiplier tube, and color filters for red and for ultraviolet light.

The red curve in the accompanying graph shows that Tycho on the eclipsed moon was dimmed by 8.1 magnitudes compared to its normal brightness on the uneclipsed full moon. In ultraviolet light, the dimming was far greater, 14.1 magnitudes, or six magnitudes deeper than in red light. Thus, the surface of the moon was dimmed in the eclipse by factors of 1/1,740 in the red, and 1/437,000 in the ultraviolet. Notice the broad, dish-shaped red light curve, and the deeper narrower ultraviolet curve. The flat portion of the latter is only one third as wide as that of the red curve.

The color index is shown in the lower part of the chart. Note the change in color of approximately 6.1 magnitudes at mid-totality compared with the normal moon. The slight downward slope of the color curve is caused by the lessening extinction of light in the earth's atmosphere as the moon reached higher altitudes late in the eclipse.

The almanac time of middle of eclipse is indicated by the arrow, and is obvi-

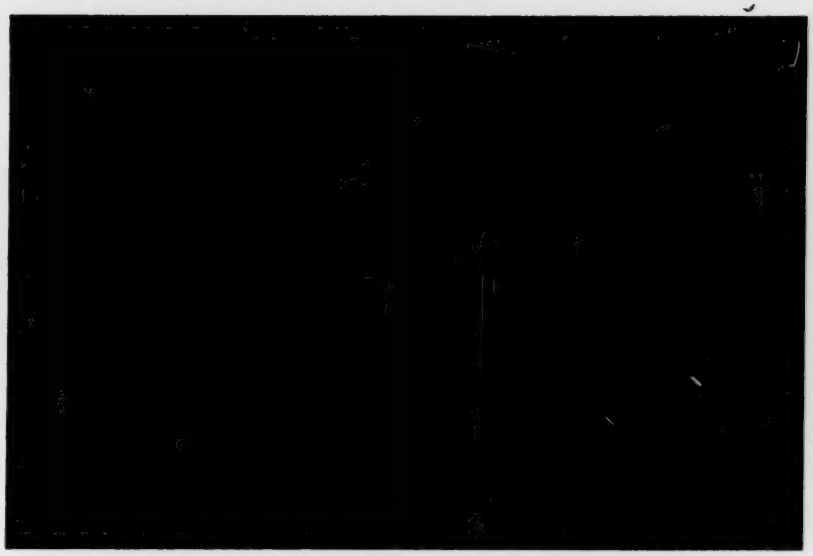


Photoelectric light curves of the region around the lunar crater Tycho during the eclipse. The color index, or difference between the red and ultraviolet curves, is plotted in the lower portion of the chart.

ously not centered symmetrically in our light curves. The observed area around Tycho, three minutes of arc in diameter, was not centrally located on the moon's disk, as already mentioned.

These observations will be further analyzed, and the details published elsewhere, in order to show the true distribution of red and ultraviolet light in the earth's shadow. Appropriate corrections have to be made to the observations to allow for the fact that the moon did not pass centrally through the earth's shadow.

JAMES CUFFEY
Indiana University



A five-minute exposure during totality on blue-sensitive film without filter. Some faint stars have been occulted. Photograph by Frank K. Edmondson, Kirkwood Observatory.

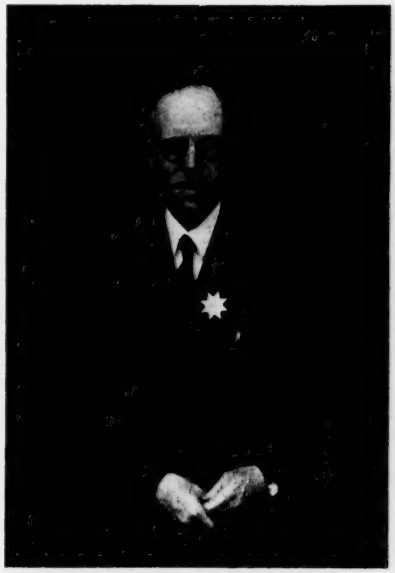
English Astronomer E. A. Milne Dies Suddenly

THE DEATH of E. A. Milne at the early age of 54, which occurred on September 22, 1950, comes as a heavy blow to theoretical astronomy in England. He may well be described as the stormy petrel of astronomy, a man who took his scientific views greatly to heart and who was passionately vigorous in defending them. In his early days in Cambridge, from 1921 onwards, he made a profound study of the theory of stellar atmospheres and of the processes by which radiation controlled their equilibrium. In this period, Milne developed a theory of the calcium chromosphere and, in collaboration with R. H. Fowler, the generalization of Saha's equations for ionization in a stellar atmosphere.

By 1930, he had turned his attention to the structure of a star as a whole and, in a now famous controversy with Eddington, defended the view that stellar models ought to be constructed by using as initial data the observed mass, luminosity, and radius of a star, to which the internal conditions must be fitted. Eddington, on the other hand, had postulated the internal conditions and derived from them his well-known mass-luminosity relation. Whilst philosophically there was much to be said for Milne's approach, the observational verification of the mass-luminosity relation argues that Eddington had guessed aright as to the internal condition of a large class of stars. But neither contestant would have welcomed the notion that both might be right!

In 1928, E. A. Milne had been appointed Rouse Ball professor of mathematics at Oxford. In 1933, while on a visit to Potsdam, he embarked on his most original and most controversial work, the theory of kinematical relativity. In this he sought to reconstruct the whole of mechanics and of electrodynamics by means of principles which were neither Newton's nor Einstein's. The fundamental system, Milne maintained, was that of the extragalactic nebulae, which must necessarily exhibit the red-shift phenomenon; we must start with a theory of this system and then work down to smaller-scale phenomena such as the motions in our solar system.

Interwoven into this scheme was, first, a theory of time and of distance and, second, a belief in the adequacy of the mathematics of special, as opposed to general, relativity. Distance is, for Milne, a notion derivative from that of time: An observer is to take as the distance of an object the (constant) velocity of light multiplied by the time-lapse on his clock between the emission and return of a light signal which goes from the observer to the object and back. But Milne argues that the rate of an observer's clock is arbitrary; there is no standard "uniform" time. Following up this line of thought, it is presently proved that the distance of the object is constant or variable according to the rate at which the observer's clock is working. In spite of the fact that distance so defined is not what physicists, surveyors, or astronomers mean by this term, Milne was able to show that kinematical relativity was invariant under Lorentz transformations and so could incorporate much of Einstein's special relativity. And it could account for the red shift, though not necessarily as a Doppler effect in the ordinary sense.



Dr. E. A. Milne at the International Astronomical Union Congress in 1948.

Difficulties — still unresolved at the time of Milne's death — were encountered when a theory of gravitation was sought. By asserting that two time-scales were in use, one for the description of the system of the extragalactic nebulae, the other for gravitational motions, Milne did succeed in producing an equation identifiable with Newton's inverse-square law of gravitation. But the more exact formulation of the gravitational problem due to Einstein, which accounts for the motion of the perihelion of Mercury, escaped Milne. Finally, he devoted much time to incorporating electrodynamics into kinematical relativity, though here, too, occasional modifications in generally accepted theory had to be made. Whether these awkward features were due, as Milne believed, to the as yet incomplete working out of his theory or whether, as many of his critics averred, they were inherent in his postulates and so inescapable, are questions that remain open at the time of his death.

G. C. McVITTIE
Queen Mary College, London

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BOOKS AND THE SKY

STELLAR EVOLUTION

Otto Struve. Princeton University Press, Princeton, N. J., 1950. 266 pages. $4.00.

AT A TIME when hypotheses and speculations on the origin and evolution of the stellar system have been appearing at a rapid rate from theoreticians, this present work by an observational astronomer is deeply appreciated. No one is better qualified to write on the evolution of the stars than is Dr. Struve; no one has a better knowledge of the complex array of facts which must be fitted into the framework of any serious theory.

The book is based on lectures given at Princeton in 1949, and consists of three meaty chapters. The first contains a brief summary of our information on the luminosities, masses, dimensions, and spectra of the stars, together with an account of their chemical composition. In the second chapter, the role of the interstellar medium is discussed, and the problem of rapidly rotating stars and shell stars. The third chapter treats of close binaries and their probable evolution.

Much attention is devoted to the chemical composition of the stars. The problem is difficult because it is necessary to separate the effects which arise from differences in physical conditions and those due to true abundance differences. Our knowledge of the composition of normal stars rests largely on discussions based on the curve of growth. In the opinion of the reviewer, the whole problem must be re-examined from the point of view of line profiles and model atmospheres, with improved values of the necessary atomic parameters.

Anomalous abundances appear to prevail in the carbon-rich **R** and **N** stars and the R Coronae Borealis stars. The Wolf-Rayet stars have long been cited as examples of objects with unusual composition, one group being rich in nitrogen and poor in carbon and oxygen, and another rich in carbon and oxygen and deficient in nitrogen. Intermediate types have been recognized among the nuclei of planetary nebulae, and the book might have mentioned that HD 45166 shows about the same type of spectrum we would expect for a Wolf-Rayet envelope of normal composition.

Helium and hydrogen are of particular interest in abundance discussions, since most stars appear to obtain their energy from the conversion of hydrogen into helium. Upsilon Sagittarii, HD 124448, and HD 30353 are examples of stars in which hydrogen is deficient.

So far no clear-cut correlations have been established between the motions of the stars and their compositions. The high-velocity stars, which presumably originated in a different part of the galaxy than stars such as the sun, do not appear to differ conspicuously in chemical composition.

At one time, differences among galactic clusters, such as the Pleiades, h and χ Persei, the Hyades, and Praesepe, were attributed to differences in hydrogen content. It now appears more likely that the hydrogen content was initially the same in all clusters. Some clusters, such as the Hyades, which contain no highly luminous stars, are relatively old. Others, such as the Pleiades or h and χ Persei, may be relatively young.

The necessity for some evolution of the stars follows at once from energy considerations. Since the conversion of hydrogen into helium seems to be the only allowed process, a star can shine only as long as its supply of hydrogen lasts. The maximum age for an **O**-type star is about 10 million years. Therefore, the stars are being formed before our eyes and our problem is to interpret correctly what we observe.

Whether the highly luminous stars are formed by the condensation of diffuse matter or by the accretion of matter by pre-existing stars drifting through a dark nebula cannot be answered at present. Perhaps both processes play a role. Furthermore, the relation between the interstellar medium and the stars is not a one-way street. Many single stars and close binary systems are surrounded by expanding shells by means of which much of the mass of the original star may eventually become dissipated in space. Novae are, of course, known to eject their envelopes into space, and the process may also occur in P Cygni and Wolf-Rayet stars. Type **B** emission stars appear to be rapidly spinning bodies (often near the limit of rota-

NEW BOOKS RECEIVED

THE EVOLUTION OF SCIENTIFIC THOUGHT, *A. d'Abro*, 1950, *Dover*. 481 pages. $3.95.

A revised and enlarged edition of a work which first appeared in 1927, this book discusses the period from Newton to Einstein, with parts on pre-relativity physics, the special theory, the general theory, and the methodology of science.

EXPLORING THE UNIVERSE, *J. Allen Hynek*, 1950, *Charles E. Merrill Co.* 32 pages.

This is a class text unit of 32 pages, size 8½ x 11¼, that is offered at five cents per copy exclusively with subscriptions for class quantities of *Current Science and Aviation*, a weekly school publication of the American Education Press, 400 S. Front St., Columbus 15, Ohio, from whom further information may be obtained.

The author is professor of astronomy and director of the McMillin Observatory at Ohio State University. He has packed the pages of this newspaper-like booklet (in two colors) with much information concerning basic and current astronomy, and he describes some practical activities for science students. In addition to the usual subjects, there is a chapter on "Rockets and Man-Made Moons," and another on, "What Has Astronomy Achieved." There are 50 photographs, drawings, and diagrams.

THE INDEX TO VOLUME IX

of Sky and Telescope is in preparation. This and the indexes to previous volumes cost 35 cents each, in coin or stamps, or included in the payment of the renewal of your subscription.

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tional stability) which eject their outer envelopes. A number of massive binaries, of which the best known is Beta Lyrae, are characterized by large streams of gas moving from the more massive component around the less massive one, forking into two streams. One of these streams returns to the large star, and the other is dissipated into space. The role of close binaries in stellar evolution appears to be a very important one.

Most single early-type stars are in rapid rotation, and it is with the development of these objects that Struve is primarily concerned. The picture of stellar evolution which he presents is briefly as follows: A portion of the interstellar cloud condenses into a rapidly spinning star of spectral class **B** and of about 10 solar masses. This star is believed to split into two rapidly spinning objects, for example, an **A** star of about four solar masses and a **G** star of about two solar masses. The system sheds material until it has evolved into a binary of the W Ursae Majoris type. The two components are of spectral class **G5**, with masses comparable with that of the sun. In the last stage of development, the components coalesce into a single star of about the solar mass, while the excess mass escapes from the system and carries away nearly all of the angular momentum. A few condensations in the tenuous envelope may be retained as planets.

In this theory the stars migrate down the main sequence, not by annihilating their mass as energy, as older evolutionary schemes suggested, but by literally throwing it away into space. This evolutionary scheme is in harmony with the observed fact that most **B** and many **A** stars rotate rapidly. Few **F**'s are in rapid rotation, and among the **G**'s and later types the only stars that spin rapidly are the components of close binary systems. The ejected gases carry away the angular momentum, and the final stage is a slowly turning star like the sun possibly surrounded by a system of planets.

One of the crucial problems of evolution is the origin of double stars. The once-popular fission theory requires objects that are more nearly homogeneous than real stars are believed to be. Struve gives considerable space to the suggestion that they originate from supernovae, but the evidence is unconvincing. The difficulty of accounting for the formation of close binaries is not an objection to Struve's theory, but is inherent in any approach to the double star problem.

Theories of stellar evolution in the past have survived for but a short period of time. This theory may suffer a similar fate when the details are worked out. Nevertheless, the theory should serve as a useful working hypothesis and a stimulant to further research.

There are a few minor errors in the text. For example, the demonstration of the similarity of composition between the stars and planetary nebulae should have been attributed to Bowen and Wyse. That the composition of the Orion nebula was the same as that of the sun was demonstrated by Wyse. In the reviewer's opinion, the book suffers from one grave defect—lack of references. Students of astronomy would have greatly profited from a selected list of papers to which they could go for an account of the original investigations.

The amateur who is acquainted with the type of material treated in a good elementary text, for example, Baker, Duncan, Skilling and Richardson, or the Harvard Books on Astronomy, should be able to read this work with great enjoyment and profit, as did the reviewer, who found it the most exciting astronomical book since Russell, Dugan and Stewart's classic appeared in 1927.

L. H. ALLER
University of Michigan Observatory

ASTRONOMY

Robert H. Baker. D. Van Nostrand Company, Inc., New York. Fifth edition, 1950. 526 pages. $4.75.

ONE'S FIRST TEXTBOOK in a subject such as astronomy is apt to become a constant reference in future years. If such a book is frequently revised by its author and brought up to date for as long as 20 years after its first publication, its value is multiplied many times. The reviewer finds it so as he compares Baker's fifth edition, dated March, 1950, with the first edition of May, 1930.

No reader of **Sky and Telescope** who has not had formal courses in astronomy need feel "lost" by reason of lack of understanding of astronomical terms and situations if he will devote time to mastering the fundamentals of the science. Baker's book and the other well-known standard texts contain the required facts and explanations. Care should be taken to understand each point before passing on to the next, for that is the method of instruction that distinguishes a textbook from other treatments of a science. It may be necessary to give a chapter repeated readings, and some explanatory paragraphs must have slow, careful scrutiny. No author is ever content with all his explanations, but there are serious limitations of space where a subject as broad as astronomy is being treated. Dr. Baker has a reputation for the soundness of his choice of topic and the lucidity of his explanations.

The recent war has been responsible for the inclusion of more material on celestial navigation in the early pages of the book. In the chapters on the solar system, there are added references to the new satellites of Uranus and Neptune, but the facts on Pluto's size and mass are already out of date! The discussion of meteors and comets reflects the advances of recent years, and the illustrations are of refreshingly recent phenomena, including the Furnas County, Neb., meteorite of February 18, 1948. Some eight pages are devoted to the current revival of interest in the origin of the solar system. A similar expansion of the problem of stellar evolution will be looked for in the next edition.

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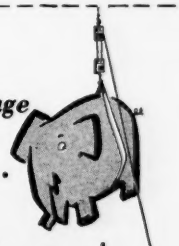

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Amateur Astronomers

THIS MONTH'S MEETINGS

Cambridge, Mass.: At the November 2nd meeting of the Bond Astronomical Club, at Harvard Observatory at 8:15 p.m., Dr. Charles Hetzler, of Ladd Observatory, Brown University, will speak on "What Is Temperature?"

Chicago, Ill.: At the November 12th meeting of the Burnham Astronomical Society, 2:30 p.m. in the auditorium of the Adler Planetarium, John Sternig, director of sciences in the Glencoe schools, will speak on "Constellations."

Cleveland, Ohio: "Interstellar Clouds" will be the subject of Dr. S. Chandrasekhar, Yerkes Observatory, speaking before the Cleveland Astronomical Society, 8:00 p.m. November 10th, at the Warner and Swasey Observatory.

Dallas, Tex.: The Texas Astronomical Society will meet Monday, November 20th, in the Dallas Power and Light auditorium, at 8:00 p.m. Miss Christine Westgate will give the lecture, "Colors of the Stars," which was not given as scheduled in August.

Detroit, Mich.: The Detroit Astronomical Society will meet on November 12th at 3:00 p.m., in State Hall, Wayne University. Dr. Orren C. Mohler, of McMath-Hulbert Observatory, will tell of his experiences at Mount Wilson this past summer.

Indianapolis, Ind.: Dr. James Cuffey, of Indiana University Observatory, will discuss "Stars and Atoms" at the November 5th meeting of the Indiana Astronomical Society, 2:15 p.m. at Cropsey Hall.

Kalamazoo, Mich.: The November 4th meeting of the Kalamazoo Amateur Astronomical Association will be in Science Hall, Kalamazoo College, at 8 o'clock, when Dr. John Hornbeck will speak on "What Is a Star?"

Minneapolis, Minn.: The Minneapolis Astronomy Club will hear the Rev. Francis Nolan discuss "European Observatories," on November 1st. Arthur T. Adams will speak on "Meteors and Comets," on November 15th. These meetings are held in the Library Science Museum at 7:30 p.m.

New Haven, Conn.: The Astronomical Society of New Haven will meet on Saturday, November 25th, in the faculty lounge, Hall of Graduate Studies, Yale University. Professor Ferris Stephens, of Yale, will speak on "Babylonian Astronomy."

New York, N. Y.: Dr. J. Lamar Worsel, geodesist at Columbia University, will talk on "The Interior of the Earth," at the November 1st meeting of the Amateur Astronomers Association, 8:00 p.m. in the lecture hall of the Roosevelt Memorial building, American Museum of Natural History.

Pittsburgh, Pa.: The Amateur Astronomers Association of Pittsburgh will meet at the Buhl Planetarium on Friday, November 10th. David A. Batchelor will lecture on "Meteors and Meteorites."

Pontiac, Mich.: Jerry Raths will talk on telescope making at the November 19th meeting of the Pontiac Amateur Astronomical Association, 3 p.m. in the Hall of Science, Cranbrook.

Rutherford, N. J.: "Practical Telescope Making" will be discussed by John L. Grinch at the November 3rd meeting of the Astronomical Society of Rutherford, in the Y.M.C.A. building at 8:00 p.m.

Washington, D. C.: The National Capital Astronomers will meet on Saturday, November 4th, at 8:00 p.m. at the Commerce Building auditorium. Dr. John S. Hall, U. S. Naval Observatory, will speak on "Some Astronomical Color Effects."

EARTH, COMETS AND METEORITES

(Continued from page 2)

fringe of the cloud would not have attained the critical density for protoplanet formation, and there (outside Neptune and Pluto) numerous small bodies should have formed, some 10^{12} of them with diameters of a kilometer or less. This number is consistent with the presently known comets, and they should be composed mostly of ices of water, carbon dioxide, methane, and ammonia.

The nature of the ices present in cometary nuclei sets limits to the gas temperatures and pressures at the time when comets developed, and hence limits the conditions under which the planets were formed, if we accept their concomitant origin, according to Dr. Fred L. Whipple, of Harvard Observatory. The evidence is strong, though not absolutely conclusive, that comets originated when the planets did, or prior to them. Dr. Whipple's picture of a comet's nucleus is that of a conglomerate of ices and meteoritic materials (see *Sky and Telescope,* October, 1949, page 308). If solid methane actually exists in comets, the sun must not have been more luminous at the time of the origin of comets and planets than it is now. Nor can the sun have lost a large part of its mass since the formation of the planets, for then the comets would also have been lost. In case the comets developed prior to the planets, the restrictions on the mass of the sun, but not on its luminosity, still apply.

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EDITED BY EARLE B. BROWN

NOTES ON THE BARLOW LENS

CORRESPONDENCE from a number of readers indicates an increasing interest in the Barlow lens, and requests for repetition of the basic formulas have been made. There has been discussion, also, of the relative merits of Barlow lenses of short and long focus.

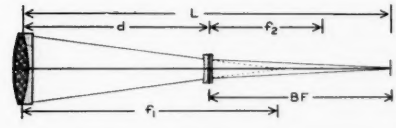
The accompanying charts give equivalent focal length (EFL) versus lens separation (**d**), and the length of instrument (**L**) from objective to focal plane versus lens separation. They are derived from values obtained by the following expressions:

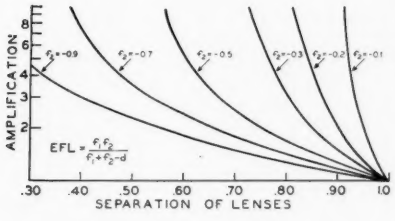
$$BF = \frac{f_2 (f_1 - d)}{f_1 + f_2 - d},$$

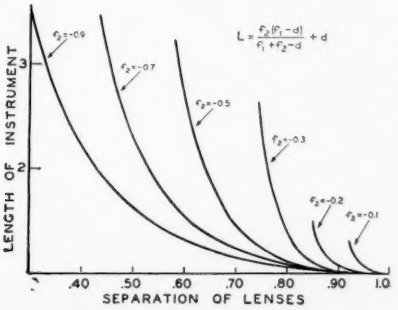
$$EFL = \frac{f_1 f_2}{f_1 + f_2 - d},$$

where the focal length of the primary mirror or objective is f_1, the Barlow focal length is f_2 (taken with a negative sign since it refers to a negative lens), and **d** is the separation of the two lenses. BF is the so-called back focus (**L** − **d**), and **L** is obviously BF + **d**.

In the charts, the unit is the focal length of the primary mirror or objective. Thus,







How a Barlow lens increases equivalent focal length, and length of instrument, depending on the separation of the objective and the Barlow. The curves are for Barlows of various powers relative to that of the objective; the right-hand curves fit most astronomical applications. The symbols are explained by the diagram at the top.

if this is 30 inches and a Barlow of −3 inches focal length is used, the curves marked $f_2 = -0.1$ would apply. Such a Barlow would obviously be placed a very short distance before the primary focal plane of the objective, and it would provide a large equivalent focal length. The resulting amplification is EFL divided by f_1, and it is this quantity that is plotted in the graph.

As the curves for the length of instrument show, for the short-focus Barlow the distance of the Barlow from the focal plane is extremely critical, and more so as the amplification is increased. A small error in the position of the Barlow will result in a large change in the position of the final focal plane. The ratio of errors may be of the order of 100 or more. Thus it is desirable that the Barlow be made adjustable; no matter how careful the original setting may have been, temperature variations may cause a noticeable shift in the position of the focal plane.

For this reason, most amateurs prefer to use Barlows of relatively short focus mounted in draw tubes that fit into the eyepiece holders of their instruments. Both Barlow tube and eyepiece may be moved to obtain the proper focus, together or separately, if necessary. In refractors, longer Barlows may also be used without difficulty, and some observers recommend Barlows as long as six inches negative focus.

In a reflector, however, such a lens presents a mounting problem. To overcome this difficulty, Francis H. Thornton, in the February, 1950, issue of the **Journal** of the British Astronomical Association, describes a method of placing the Barlow inside the main tube of an 18-inch reflector, stating:

"We come to the placing of the lens in the cone of rays from the mirror. Assuming 2½ inches as a convenient and workable distance inside the prime focus, we have an amplification of 6, and an extension of 15 inches [for a 3-inch Barlow]. It is evident that it will be feasible to mount the lens right in the middle of the tube and still have sufficient extension for half the diameter of a large tube and a normal draw tube mount.

"And a very important point becomes apparent. The 3-inch [Goerz telenegative] lens will accommodate comfortably the cone of rays from the mirror if placed 2½ inches inside the [original] focus, so that the diagonal, whether flat or prism, does not need to be any larger than the lens in its cell, or 1¾ inches.

"Thus there is the minimum possible interference with the incoming light. So we can start by considering the lens mounted immediately below the diagonal, and the best form of diagonal to use is a prism, under which the lens can be mounted in any convenient manner. A good method is to cement the retaining ring of the cell to the glass, which enables one to remove cell and lens at any time simply by unscrewing the cell from its ring. This method has the additional advantage in

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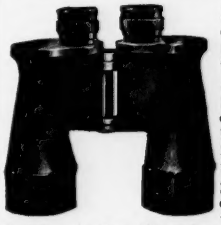

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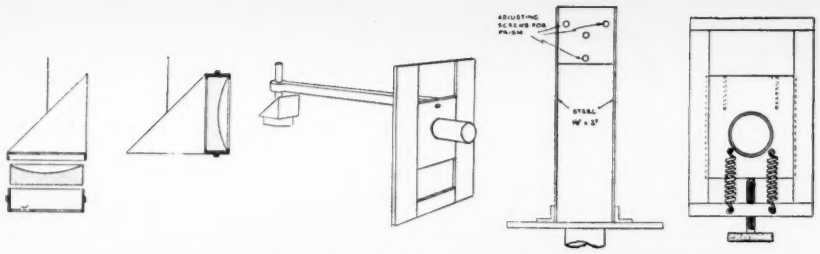

For a Barlow of three inches negative focus in an 18-inch reflector, Francis H. Thornton proposes two interchangeable positions before or after the prism diagonal, as shown above at the left. For the type of mounting of prism and Barlow shown in the center drawing he suggests the two thin steel supports to the right. Springs under tension provide a satisfactory method of holding the whole assembly in its ways on the outside of the telescope tube. Diagram from the "Journal" of the British Astronomical Association.

that the lens may, by reversing the prism, be placed either on the mirror side of the diagonal mount or on the eyepiece side, thus providing two different ranges of effective focal length. When turned to the latter position, it is necessary to unscrew the cell from its retaining ring, reverse the lens in its cell, and screw on again. The prism must then be moved nearer to the mirror by approximately two inches.

"However, it still accommodates the whole cone of rays with something to spare. In this second position, the extension is smaller and the amplification less. The draw tube must also be moved downwards to preserve the essential relationship with the lens, and a little thought will make it obvious that there is a considerable difficulty which has to be overcome. . . ."

Mr. Thornton goes on to discuss a method for mounting the prism-Barlow combination on a stiff arm, "firmly and squarely attached to the draw tube mount, this latter being arranged to slide up or down the main tube in parallel guides." The accompanying copies of his diagrams illustrate the method. He points out that the prism must have screw-controlled movements for adjustment, and its upright edges must be parallel to the guides. The adjustment of the lens-prism combination is made perfect without any reference to the mirror, as a mirror, and once it is properly completed it is done for good. He states that this arrangement gives excellent results in practice, and is an enormous improvement over the draw tube position for the Barlow lens, and he closes:

"In conclusion, the handiness and comfort gained by this arrangement, and the superb definition aided by precision in adjustment, have made it unthinkable that the writer should ever revert to the plain Newtonian form of reflector."

With respect to the performance of a Barlow, the problem is no different from that of any instrument. There is nothing magical about a Barlow lens—it is merely a convenient way of making a long-focus high-magnification instrument without using too much space. It is the exact equivalent of a Cassegrainian reflector, except it makes use of a lens instead of a mirror and avoids some of the other disadvantages of the Cassegrainian. In either case, it is important to have a nearly perfect objective. There is no use, of course, in trying to build any kind of astronomical

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telescope without a good astronomical objective. And with a good objective, a Barlow lens gives a very convenient high-magnification arrangement. The addition of a Barlow lens cannot improve the imagery of a mediocre lens or mirror.

The same limitation which we have pointed out in this column many times with respect to eyepieces and the use of war-surplus optics applies here. Lenses that have been designed for one application will almost always give mediocre performance when used in a different way. Lenses that have not been designed to be used together will not give superior results when they are combined in an instrument, and superior results are essential in astronomical applications. In some cases, however, as with eyepieces, the incompatibility is not of sufficient magnitude to be serious, and an eyepiece designed for a binocular may prove satisfactory with a parabolic mirror. Where the Barlow is of short focus, this same tolerance may be applied, except with instruments of small focal ratios, such as f/4, for which a perfect achromatic Barlow should be used.

When the Barlow is considered an internal component of the instrument, the incompatibility may be more serious, especially for small objectives, where the resolving power is low. If, for example, a 2-inch, f/15 objective is used directly with a 1-inch eyepiece, the magnification is 30x. With a resolution of six seconds for the objective, not beyond expectations for a good lens, the resulting definition would be "reasonably good." If a Barlow is used to increase the focal ratio to f/45, the magnification becomes 90x and the required resolution on the part of the objective becomes two seconds of arc for equal visual definition. The theoretically perfect 2-inch objective will have a resolution of 2¼ seconds, so such an arrangement could give "reasonably good" definition only if both objective and Barlow were absolutely perfect, and also of the proper design to work with each other. The best design of a system consisting of two doublets would not be when they are separately aplanatic. Unless we start with a nearly perfect objective, it is futile to put a Barlow behind it, since the only result will be to magnify the imperfections.

Unfortunately, some confusion has resulted from the diagram that accompanied B. C. Parmenter's description of his planetary telescope in the issue of October, 1949, page 316. The drawing he supplied was intended to indicate the closeness of the Barlow to the objective compared with the equivalent focal length achieved by the combination. In Mr. Parmenter's case, the actual distance of a 5-inch Barlow from the objective (30 inches focal length) would be slightly over 25 inches for the amplification of over 20 times that he employed. For a 4-inch Barlow, the value of **d** would have to be slightly over 26 inches. In neither case could the Barlow be placed nearer the objective, as then the rays would diverge and there would be no real focal plane. As the Barlow is moved toward the objective a distance from the primary focus almost equal to its negative focal length, the "focal planes" of the Barlow and the objective almost coincide. The curves of the graphs rise almost vertically at this point, showing that a very small change of distance greatly increases both the length of the instrument and the effective focal length.

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CONCERNING HALOS

The description of halos in the June issue, pages 188 and 191, as observed by Mr. Pilsworth and Mr. Wilson includes some halo phenomena which are rarely seen. Mr. Pilsworth observed the rare elliptical halo, tangential arcs, and the 360-degree horizontal circle. Mr. Wilson also saw the horizontal circle and on it at a distance of 120 degrees from the sun a sundog. The sundogs not being on the 22-degree ring, as he wrote, seems to indicate a 44-degree halo, itself not visible.

Regular observations of halos and associated fainter phenomena can easily be made, and the writer is willing to collect such observations for scientific research. An experienced observer sees annually between 60 and 100 solar and lunar halos.

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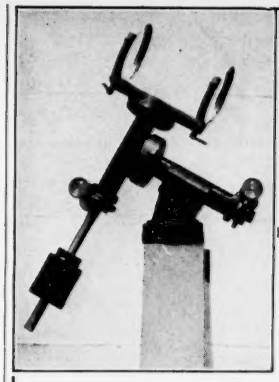

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Although the Saturn 3 Inch Refractor has a 45 inch focal length, the instrument is easily portable, weighing less than thirty pounds, including tripod.

Saturn 4 Inch Portable Refractors from $345.00; larger instruments manufactured to order.

Write for literature giving full information on the Saturn Refractors.

Tinsley
2530 Grove Street
Berkeley, California

OBSERVER'S PAGE

Universal time is used unless otherwise noted.

Visual Observing Programs for Amateurs — VIII

Accessories

EYEPIECES. I wear glasses at the telescope, and these force my eye back about an inch from the eye lens of the eyepiece. This limits the field of view which I can see with my prewar Huygenian and Ramsden eyepieces, for in general they do not have high eye relief.

Almost all of the wartime eyepieces that I have bought since 1945 have high eye relief, so that despite my glasses I can see their full field of view. The symmetrical or double achromatic eyepieces are a very serviceable tribe. I have been able to secure or assemble these in focal lengths of 0.5, 0.75, 0.787, 1.0, and 1.25 inches. The four powers, 0.5, 0.75, 1.0, and 1.25, cover most amateur needs except for planetary and double star work. All but the 0.5-inch have high eye relief. Their apparent field of view is around 48 degrees. These eyepieces are all small enough in diameter so that they can be mounted in 1¼″ o.d. bushings for use in standard 1¼″ i.d. telescope tubes.

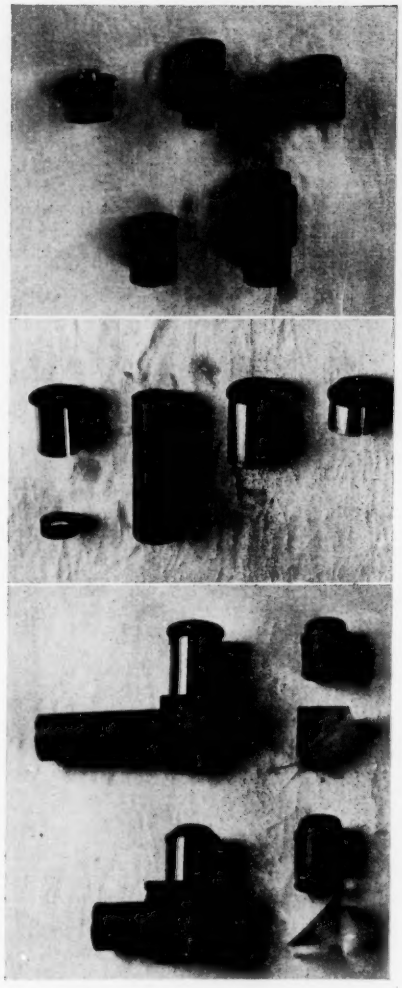
The Erfle-type wartime eyepieces give very wide fields of view and high eye relief. I have bought these in 1½″ and 1¼″ e.f.l. sizes. Their apparent field of view is 75 degrees. They are so large in diameter that they have to be fitted into bushings of 2″ o.d., and I have equipped two of my refractors with tailpiece tubes 2″ i.d. to hold them. When I want to use standard 1¼″ o.d. eyepieces, I insert a 2″-1¼″ bushing in the tailpiece tube.

For planetary work, orthoscopic eyepieces are highly recommended. At least for a while after 1945, powers of 32 mm., 27 mm., 1″, 20 mm., 2/3″, 16 mm., 1/3″, 8 mm., and perhaps others were available. Their apparent field of view is 48 degrees. Down to the 16-mm. size they have high eye relief. As far as the writer knows, only the 32 mm., 1″, 2/3″ and 1/3″ are now available to amateurs, and the latter three probably only by special order. However, these sizes amply suffice, especially when used with a Barlow to increase their power.

Barlows and Erectors. Two devices are available to increase the power of an eyepiece. If the eyepiece by itself has good eye relief it will still have the same characteristic if used with either a Barlow or an erector.

The Barlow which I have consists of a negative achromatic lens of around −1.75″ e.f.l. in the front end of a brass tube about four inches long. It is used mostly with my 32-, 27-, 20-, and 16-mm. orthoscopics. It increases their power by approximately three times, so that in round figures it gives me eyepieces of 11-, 9-, 7-, and 5-mm. e.f.l., in addition to the original 32, 27, 20, and 16. In use, the eyepiece is about two inches farther out with the Barlow than without it.

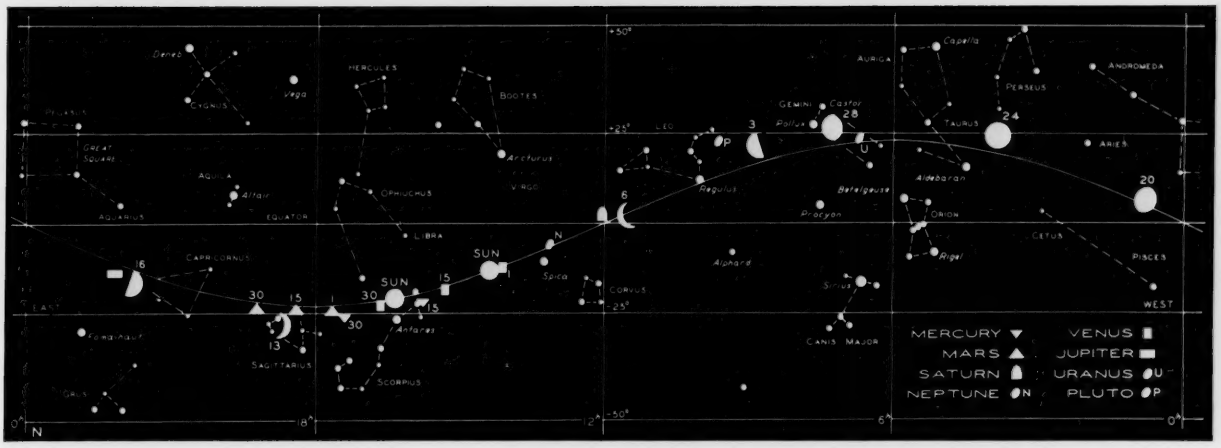
Other amateurs use Barlows of about −3″ e.f.l. to good advantage, which give a factor of about 2.75x. I made one of −6″ e.f.l. myself, but did not find it satisfactory as it only gave a factor of 1.4x, did not give good definition at the edges, and it was too long for convenience.



David Rosebrugh's accessories include (top) five eyepieces assembled from wartime equipment; (middle) a Barlow lens in a 4-inch adapter tube, with its optics shown at the left, and 32-mm. and 16-mm. eyepieces used with it at the right; (bottom) a zenith prism and below it a solar eyepiece assembly, with the optics of each shown at the right.

The erector is a symmetrical double achromatic positive lens of about 1″ e.f.l. inserted in front of the eyepiece. I made one in accordance with the instructions which appeared in this magazine some years ago. It seems to give good definition at high powers, but it forces the eyepiece about six inches farther out from the telescope than when it is not in use, which is inconvenient. Moreover, it produces an erect image, which is a nuisance in several ways when using an astronomical telescope. In a refractor, however, one can use it as a terrestrial erector so that the telescope can be used for spyglass purposes.

In practice, I greatly prefer the Bar-



low, which I carry in a little traveling kit together with my orthoscopic eyepieces. This kit gives me practically every combination of field and power I can require, from the wide angle and low power of the 32-mm. used by itself to the high power of the 16-mm. used with the 3x Barlow. My 1/3″ orthoscopic eyepiece gives impossibly high powers with the 3x Barlow, so it is used by itself when required. Actually, the 32-mm. and 16-mm. eyepieces and the 3x Barlow give me almost the complete range of powers that I need for every purpose.

Zenith Prism. This is a right-angle totally reflecting prism placed in the optical axis of a refractor just ahead of the eyepiece in such a way as to reflect the light out at right angles. The eyepiece is placed close to the prism. When used with a refractor it is possible to point the telescope toward the zenith and yet look horizontally into the eyepiece. Unfortunately, the single reflection reverses the image. Thus, it is hard to identify variable star fields unless one uses a reversing box, as do some observers with a Springfield-mounted Newtonian reflector, in which three reflections produce the same reversed image. Planetary images, too, are reversed. However, for occultations, simple stargazing, and terrestrial work it has merits. When a zenith prism is used with a refractor for spyglass purposes, one must look vertically downward into the eyepiece. Right and left are reversed, but the image is erect and quite usable.

Solar Prism. This is similar to the zenith prism, but instead of being mounted so that it is totally reflecting, the prism is turned over and the sun's light is reflected off the hypotenuse of the prism toward the eyepiece. Only about five per cent of the light is reflected out at right angles toward the eyepiece, and this is further cut down by a factor of about 700 by a dark filter. Thus, the image of the sun is dimmed about 14,000 times before one observes it. The 95 per cent of the sun's light which is not reflected out at right angles to the eyepiece passes through the prism, is refracted somewhat toward the base, and passes out the back of the prism. Provision should be made to allow the heat to escape either through ventilating holes or a negative lens.

DAVID W. ROSEBRUGH
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THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury enters the evening sky on November 1st, passing the sun in superior conjunction. Elongation is not attained till mid-December; however, the planet may be located the last few days of November, setting three quarters of an hour after the sun.

Venus passes superior conjunction with the sun on the 13th, moving into the evening sky. The planet will not become visible until late December as its eastward motion away from the sun is slow.

Mars, an inconspicuous object at magnitude +1.3, continues traveling east of the sun in Sagittarius, setting 2½ hours after sunset.

Jupiter is on the meridian as evening twilight ends, remaining the brightest object in the sky. Its stellar magnitude is −2.1, outshining Sirius by half a magnitude. Eastern quadrature with the sun occurs on November 21st, hence the planet must set around midnight. The Jovian disk remains large, with the equatorial diameter 42″ at the beginning of the month.

Saturn will precede the sun by 3½ to 5½ hours in the morning sky. The planet will continue moving slowly eastward about halfway between Regulus and Spica, at the same magnitude as the latter. The Saturnian ring system now presents its northern face, which is gradually opening; it has an inclination of 3°.1 on the 15th.

Uranus, of the 6th magnitude, is an easy object in opera glasses. It is about 2° south of Epsilon Geminorum, in retrograde motion.

Neptune is in proximity to the sun in the morning sky. E.O.

DEEP-SKY WONDERS

MARALDI discovered the bright globular **NGC 7078,** M15, $21^h\ 27^m.6$, +11° 57′, on September 7, 1746. He is also credited with another globular, **NGC 7089,** M2, $21^h\ 30^m.9$, −1° 3′, on September 11, 1746. Thus in but five days he found all the globulars his astronomical career was to yield. M15 and M2 both have diameters of about 12 minutes of arc, and each has a total magnitude of 7.7.

Such similarity in discovery date, brightness, size, and region of the sky is most unexpected.

The dates are from Helen Hogg's fine monograph, but Smyth gives 1745 for M15. He adds that M2 was found during the search for Cheseaux's comet. Good-sized amateur telescopes will resolve the edges of both clusters on fine evenings.

NGC 16, 15^4, $0^h\ 6^m.5$, +27° 27′. This is a 13th-magnitude round external galaxy which Herschel mistook for a planetary. It is invisible in a 6-inch but steady in a 16-inch telescope.

WALTER SCOTT HOUSTON

METEORS IN NOVEMBER

Two meteor showers may be noted this month by watchers of the sky. The Taurids begin in late October and continue through November 22nd. However, the favorable time for observation will occur from November 3rd to 10th (shower maximum), and the moon will be nearly absent from the sky in that period. Rates are rather low—about six per hour may be seen with clear skies. Taurids are of the slow type and radiate from a point 10° south of the Pleiades. As the Taurid radiant transits shortly after midnight, the Taurids are a relatively good early-evening shower.

The Leonids are of little current interest but should be mentioned. Maximum takes place on the morning of the 16th, while limits of the shower are from the 15th to 20th. Preceding dawn, one will notice very swift meteors, rather faint but many of them with trains, coming from Leo. The B.A.A. predicts rates of six per hour from a radiant close to Gamma Leonis. The radiant transits during the dawn. E. O.

PHASES OF THE MOON

Last quarter	November	3, 1:00
New moon	November	9, 23:25
First quarter	November	16, 15:06
Full moon	November	24, 15:14
Last quarter	December	2, 16:22

	November	Distance	Diameter
Perigee	$10^d\ 13^h$	222,000 miles	33′ 26″
Apogee	$25^d\ 0^h$	252,600 miles	29′ 24″
	December	**Distance**	**Diameter**
Perigee	$9^d\ 1^h$	221,700 miles	33′ 29″

OCCULTATION PREDICTIONS

November 23-24 **Eta Tauri** 3.0, 3:44.5 +23-57.1, 14, Im: **C** 11:23.5 +0.3 −1.2 93; **D** 11:18.3 +0.1 −1.2 84; **E** 11:24.9 +0.1 −1.7 107; **G** 10:56.5 −0.8 −1.7 93; **I** 10:50.6 −1.1 −2.0 102. Em: **E** 12:19.7 −0.1 −0.4 240; **G** 12:04.5 −0.6 −0.9 247; **I** 11:58.5 −0.9 −0.3 235.

December 26-27 **Gamma Cancri** 4.7, 8:40.4 +21-39.0, 18, Im: **A** 6:16.4 −1.6 −1.6 136; **C** 6:17.0 −1.4 −2.8 155; **E** 5:52.7 −1.6 −2.8 158; **H** 5:18.2 −1.4 −2.4 161. Em: **A** 7:38.6 −2.1 −0.6 278; **B** 7:34.0 −1.8 −0.9 286; **C** 7:27.7 −2.8 +0.8 257; **D** 7:23.3 −2.2 0.0 273; **E** 6:51.0 −2.3 +2.6 242; **G** 6:31.8 −1.0 +1.0 283; **H** 5:54.9 −0.1 +4.1 224; **I** 6:22.3 −0.8 +1.1 282.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, **UT**, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5, +42°.5	**E**	+91°.0, +40°.0
B	+73°.6, +45°.6	**F**	+98°.0, +31°.0
C	+77°.1, +38°.9	**G**	+114°.0, +50°.9
D	+79°.4, +43°.7	**H**	+120°.0, +36°.0
		I	+123°.1, +49°.5

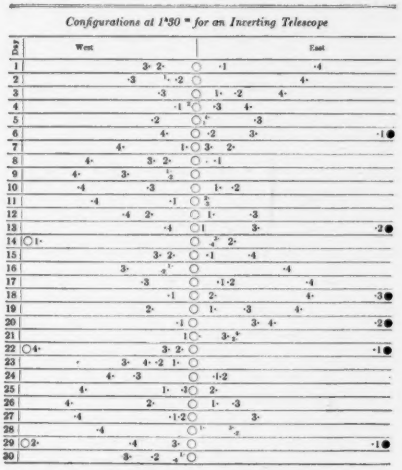
VARIABLE STAR MAXIMA

November 4, R Virginis, 6.9, 123307; 8, S Carinae, 5.7, 100661; 10, V Monocerotis, 7.1, 061702; 11, R Leonis, 5.9, 094211; 24, T Ursae Majoris, 7.9, 123160; 25, U Herculis, 7.6, 162119; 27, RS Librae, 7.7, 151822.

These predictions of variable star maxima are by Leon Campbell, honorary recorder of the AAVSO. Only stars are included whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the **American Ephemeris and Nautical Almanac.**



MINIMA OF ALGOL

November 1, 18:24; 4, 15:13; 7, 12:01; 10, 8:50; 13, 5:39; 16, 2:28; 18, 23:17; 21, 20:06; 24, 16:55; 27, 13:44; 30, 10:33. December 3, 7:22; 6, 4:11.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See **Sky and Telescope, Vol. VII,** page 260, August, 1948, for further explanation.

PREDICTIONS OF BRIGHT ASTEROID POSITIONS

No. 16	**Psyche**	Mag. 9.2	
	h m	° ′	
Nov. 5	5 04.4	+18	13
15	4 58.0	+17	55
25	4 49.8	+17	38
Dec. 5	4 40.8	+17	22
15	4 31.9	+17	10
25	4 24.2	+17	04
No. 6	**Hebe**	Mag. 8.1	
	h m	° ′	
Dec. 5	6 37.1	+03	10
15	6 28.3	+03	39
25	6 17.9	+04	36
Jan. 4	6 07.6	+05	55
14	5 58.8	+07	26
24	5 52.9	+09	08
No. 37	**Fides**	Mag. 9.3	
	h m	° ′	
Nov. 25	6 20.6	+28	24
Dec. 5	6 13.7	+28	44
15	6 04.2	+28	56
25	5 53.6	+28	59
Jan. 4	5 43.7	+28	53
14	5 36.1	+28	38

The above are predicted positions in right ascension and declination for the epoch 1950.0, for 0ʰ Universal time. The magnitude is that expected at opposition. In each case the motion of the asteroid is retrograde.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evening, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BOSTON: *Little Planetarium.* Boston Museum of Science, Science Park, Boston 15, Mass. Richmond 2-1410.

SCHEDULE: Tuesday thru Friday at 3:30 p.m.; Saturday, 2:00 and 3:30 p.m.; Sunday, 3 and 4 p.m. Spitz projector. In charge, Charles A. Federer, Jr.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector. For special lectures address Elsworth Jaeger, director of education.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.

SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Director, Roy K. Marshall.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 1, Mo., Chestnut 2215.

SCHEDULE: Wednesday and Saturday, 3:30 p.m.; Sunday, 3:00 and 5:00 p.m. Spitz projector. Director, Charles G. Wilder.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Wednesday and Thursday at 8:30 p.m.; Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Acting Chairman, Robert R. Coles.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PORTLAND, ORE.: *Spitz Planetarium.* Oregon Museum of Science and Industry, 908 N.E. Hassalo St., Portland 12, Ore., East 3807.

SCHEDULE: Tuesday through Sunday, 4:00, 7:30, and 8:30 p.m.; Saturday show for tots, 10:30 a.m. Special group lectures by request. Spitz projector. Director, Stanley H. Shirk.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

SCHEDULE: Sunday, 4:15 p.m. Special showings on request. Admission free. Spitz projector. Director, Robert E. Cox.

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of November, respectively.

STARS FOR NOVEMBER

PISCES AND CETUS approach the meridian these fall evenings to join the "watery" region populated by Aquarius and Capricornus. Alpha Piscium is called Al Rischa, the Knot, where the pair of fishes are joined by their tails. Although Pisces is a rather dim constellation consisting of 4th- and 5th-magnitude stars, the two star streams are easy to trace out. The chart shows five stars in the Circlet of the western fish, but a total of seven are easily seen on a clear night. Pisces is the first constellation of the zodiac now, containing the vernal equinox. This point of the sky has precessed westward from Aries in 2,000 years, but the sign of Aries has been retained as the symbol of this equinox. Observers in the Southern Hemisphere prefer to call it the March equinox, for it marks the beginning of autumn, not of springtime, in mid-southern latitudes.

Cetus is the sea monster associated with the mythology of Perseus and Andromeda. The long sprawling pattern marks out a lounge chair, with Deneb Kaitos, the Whale's tail, to the west as the footrest. The famous long-period variable, Omicron Ceti, or Mira (the Wonderful), is in Cetus.

CHART CORRECTION: The Greek letters for Beta and Gamma Lyrae should be exchanged.